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A CASE STUDY ON THE RELATIONSHIP BETWEEN OPM-CRUSADER, UDLP, AND TACOM-ARDEC IN THE DEVELOPMENT OF THE CRUSADER ARMAMENT

by
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December 1997

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The purpose of this research paper is to analyze the relationships between the Office of the Project Manager - Crusader (OPM-Crusader), the U.S. Army Armament Research, Development and Engineering Center (a component of the U.S. Army Tank-automotive and Armaments Command, abbreviated TACOM-ARDEC), and United Defense Limited Partnership (UDLP) in the development and delivery of the Crusader Armament System. These relationships are unique because, although the armament system is being developed by TACOM-ARDEC and manufactured by Watervliet Arsenal, it is not being supplied to UDLP as Government-Furnished Property (GFP). Rather, a teaming relationship has been developed directly between TACOM-ARDEC and UDLP. OPM-Crusader transfers funding to TACOM-ARDEC which performs the work under the technical and programmatic direction of UDLP. TACOM-ARDEC's role is similar to that of a subcontractor. This research paper examines the relationships between the organizations, and contrasts them to the relationships that are found in traditional GFP situations. The research showed that these relationships should result in a better designed howitzer at a lower cost the Government.

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A CASE STUDY ON THE RELATIONSHIP BETWEEN OPM-CRUSADER, UDLP, AND TACOM-ARDEC IN THE DEVELOPMENT OF THE CRUSADER ARMAMENT

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Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

The purpose of this research paper is to analyze the relationships between the Office of the Program Manager - Crusader (OPM-Crusader), the U.S. Army Armament Research, Development and Engineering Center (a component of the U.S. Army Tank-automotive and Armaments Command, abbreviated TACOM-ARDEC), and United Defense Limited Partnership (UDLP) in the development and delivery of the Crusader Armament System. These relationships are unique because, although the armament system is being developed by TACOM-ARDEC and manufactured by Watervliet Arsenal, it is not being supplied to UDLP as Government-Furnished Property (GFP). Rather, a teaming relationship has been developed directly between TACOM-ARDEC and UDLP. OPM-Crusader transfers funding to TACOM-ARDEC which performs the work under the technical and programmatic direction of UDLP. TACOM-ARDEC's role is similar to that of a subcontractor. This research paper examines the relationships between the organizations, and contrasts them to the relationships that are found in traditional GFP situations. The research showed that these relationships should result in a better designed howitzer at a lower cost the Government.

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LIST OF ACRONYMS

ACAT	Acquisition Category
AEF	Allied Expeditionary Force
AMC	Army Materiel Command
AWACS	Airborne Warning and Control System
CAD/CAM/CAE	Computer Aided Design/Computer Aided Manufacturing/Computer Aided Engineering
CSCSC	Cost/Schedule Control Systems Criteria
COTR	Contracting Officer's Technical Representative
CPIF/AF	Cost-Plus-Incentive-Fee/Award-Fee
DCMC	Defense Contract Management Command
DoD	Department of Defense
DoDD	Department of Defense Directive
EVMS	Earned Value Management System
FAR	Federal Acquisition Regulation
G&A	General and Administrative
GFM	Government-Furnished Material
GFP	Government-Furnished Property
GOCO	Government-Owned, Contractor-Operated
HIP	Howitzer Improvement Program
IOC	Industrial Operations Command
IPT	Integrated Product Team

MOA	Memorandum of Agreement
OPM	Office of the Program Manager
PCO	Procuring Contracting Officer
PDRR	Program Definition and Risk Reduction
SOW	Statement of Work
TACOM	Tank-automotive and Armaments Command
TACOM-ARDEC	TACOM's Armaments Research, Development, and Engineering Center
TECOM	Test and Evaluation Command
UDLP	United Defense Limited Partnership
USG	United States Government

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I. INTRODUCTION

A. GENERAL INFORMATION

The purpose of this research paper is to analyze the relationships between the Office of the Program Manager - Crusader (OPM-Crusader), the U.S. Army Armament Research, Development and Engineering Center (a component of the U.S. Army Tank-automotive and Armaments Command, abbreviated TACOM-ARDEC), and the prime contractor, United Defense Limited Partnership (UDLP), in the development and delivery of the Crusader Armament System[1]. These relationships are unique because, although the armament system is being developed by TACOM-ARDEC's Fire Support Armament Center and Benet Laboratories and manufactured by the Army's Watervliet Arsenal, it is not being supplied by OPM-Crusader to UDLP as Government-Furnished Property (GFP). Rather, a teaming relationship has been developed directly between TACOM-ARDEC and UDLP. At the direction of the Honorable Gilbert Decker, the former Army Acquisition Executive, a Memorandum of Agreement (MOA) was developed between UDLP and TACOM-ARDEC. UDLP reports work to be performed by TACOM-ARDEC and submits requests for TACOM-ARDEC funding to OPM-Crusader. Once approved, OPM-Crusader transfers funding to TACOM-ARDEC which performs the work under the technical and programmatic direction of UDLP.

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[1] The Armament System includes both the XM297 Cannon Assembly, which consists of the tube, breech, and ignition system, and the XM183 Gun Mount which consists of the cradle structure and the recoil and recuperator mechanisms. Pictures of the Armament System are included in Appendix A.

This research paper will examine the relationships between OPM-Crusader, UDLP, and TACOM-ARDEC, and contrast them to the relationships that are found in traditional GFP situations. This research will analyze the arrangement, showing the advantages and disadvantages of the unique Crusader program relationships.

B. RESEARCH QUESTIONS

1. Primary Research Question

What are the key elements of the relationship between OPM-Crusader, UDLP and TACOM-ARDEC in the development and delivery of the Crusader Armament System?

2. Secondary Research Questions

a) What are the principal elements of the MOA between UDLP and TACOM-ARDEC?

b) What are the advantages of the relationship between OPM-Crusader, UDLP and TACOM-ARDEC compared to traditional GFP relationships?

c) What are the disadvantages of this relationship compared to a traditional GFP relationship?

d) What have been the principal problems in executing this relationship and how have they been resolved?

e) For future research: How might a relationship like the one between UDLP and TACOM-ARDEC be utilized effectively in other system acquisition situations?

C. DISCUSSION

The Crusader self-propelled howitzer is an ACAT ID Army program that will provide mobile protected fire support to America's maneuver forces in the 21st Century. The range requirement for the Crusader has been set at 40 plus kilometers with assisted (i.e., rocket assisted) projectiles. The rate of fire requirement is ten to twelve rounds per minute [Ref. 1]. These demanding requirements rule out any cannon system currently in use by the United States or any other country.

The cannon originally being developed for the Crusader howitzer was to have been a liquid propellant design. Engineering difficulties relating to the storage and stability of the liquid component, along with other factors, led to the cancellation of the liquid propellant cannon system in March of 1996.

The Crusader prime contractor, United Defense Limited Partnership, was forced to look for an alternative cannon design that would still meet the Crusader range and rate of fire requirements. UDLP solicited proposals through the Commerce Business Daily. Respondents included Lockheed Martin Defense Systems, the United Kingdom's Royal Ordnance, Rheinmetal of Germany, and TACOM-ARDEC [Ref. 2]. UDLP selected TACOM-ARDEC's design based upon the XM297E2 cannon as a best value solution [Ref. 3].

The Crusader is the Army's flagship development program and has been involved with acquisition reform since its outset [Ref. 3]. In the interest of streamlining and consolidating responsibility on the prime contractor, Mr Decker decided that minimal Government-Furnished Property (GFP) would be used in the procurement. When asked specifically about the armament system, traditionally provided as Government-Furnished Material[2] (GFM) in howitzer and tank systems, he repeated his "no GFP" edict [Ref. 4]. In fact, the only GFP items used in the Crusader system are the ammunition, propelling charges, and prototype cannons for testing.

To comply with the Army Acquisition Executive's direction, OPM-Crusader directed UDLP to coordinate with TACOM-ARDEC directly to develop a working relationship. The result was a Memorandum of Agreement signed between UDLP's Crusader Program Director and TACOM-ARDEC's Technical Director on 6 November 1996. This MOA laid out the working relationships, provisions for engineering services, and the Statement of Work (SOW). This MOA emphasized that work performed by TACOM-ARDEC for UDLP would not be "construed as Government-Furnished services" and that, "Any inconsistencies between the terms of the contract and this MOA shall be resolved based on the terms of that contract."[Ref. 5]

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[2] Government-Furnished Material (GFM) is a sub-set of GFP that includes items which are components of the end item. This distinguishes GFM from other types of GFP such as facilities, manufacturing equipment, test and diagnostic equipment, and computers used in design and manufacturing.

Although it is not mentioned in the MOA, the role of the OPM-Crusader is to provide overall program management over UDLP, its subcontractors, and TACOM-ARDEC. They do this using an Integrated Product Team (IPT) approach. On a quarterly basis UDLP submits a funding request to OPM-Crusader for the work to be performed by TACOM-ARDEC over the next three months. OPM-Crusader then transfers funding to TACOM-ARDEC [Ref. 6]. UDLP does not pay TACOM-ARDEC directly, and OPM-Crusader is not directly involved (outside of normal IPT functions) with design, production or delivery issues between TACOM-ARDEC and UDLP.

D. SCOPE OF THESIS

This thesis will be a case study that analyzes the relationship between OPM-Crusader, the prime contractor UDLP, and TACOM-ARDEC. It will explain the responsibilities of each party and how they coordinate with each other. The research will diagram the management and information flow between the parties, as well as the funding and materials flow.

The traditional GFM relationships for howitzer and tank systems will be used to compare and contrast to the Crusader relationship. They will also be diagrammed.

Specific factors such as cost and manpower savings, technical risk reduction, and schedule risk reduction will be analyzed. The research will breakdown all the administrative burdens that are normally incurred with GFM, and contrast them to the Crusader Program. The net effect of this reduced oversight on both the Program Management Office and prime contractor will be detailed.

Provisions for late or defective GFP will be examined in detail and related to the current Crusader arrangement. Provisions for program cancellation, termination for convenience, and termination for default will also be examined in detail.

The implications of Government agencies acting in a role similar to that of a subcontractor will be explored in the light of acquisition reform and "reinvention" of Government. Government/Contractor teaming will be highlighted. The focus will be on how the Crusader arrangement compares to traditional GFP arrangements in terms of cost and efficiency. The legal ramifications of Government employees' working relationships with contractor employees will not be addressed.

This arrangement may be suitable for other howitzer and tank systems that will utilize armament designed and/or manufactured in Government laboratories and arsenals. Elements of this arrangement may also be suitable for a myriad of other programs that use equipment or services provided by Government agencies.

E. METHODOLOGY

Traditional GFM working arrangements were researched by a literature review. This included Federal, DoD, and Army regulations and reports, books, and periodicals. These materials were obtained from the Naval Postgraduate School Library and Acquisition Library, the Defense Technical Information Center, and the Defense Logistics Studies Information Exchange. Additional information was obtained from the Defense Acquisition Deskbook and the Internet.

Because the Crusader is an ongoing program and the working arrangement between TACOM-ARDEC and UDLP is so new, the above methods were of limited use in researching the Crusader relationships. Instead, the researcher conducted interviews and submitted questions by electronic mail to involved personnel from OPM-Crusader, UDLP, and TACOM-ARDEC.

F. CHAPTER OUTLINE

1. Introduction

Chapter I provides an introduction to the Crusader armament development program and indicates the focus and purpose of the thesis. The primary and secondary research questions are identified.

2. Background

This chapter provides a historical perspective of how cannons were traditionally provided as GFM to tank and artillery systems. The beginnings of cannon manufacturing by the Government at Watervliet during the Revolutionary War, operations during the Civil War, and the World Wars are outlined for historical perspective.

The details of the GFM operations for the M109 series howitzer (the platform that Crusader will replace) and the M1 series tank are closely scrutinized. The associated problems in coordinating, delivering and accounting for the GFM are examined, along with the associated costs and administrative requirements.

Finally, GFM is examined in light of acquisition reform. The underlying reasons for the decision to avoid GFM on the Crusader program are studied. The hoped for benefits in terms of efficiency and cost of the "no GFM" decision are explained.

3. Details of the Memorandum of Agreement

This chapter fully explains the working relationship between UDLP and TACOM-ARDEC and shows the duties and responsibilities of each. The role of OPM-Crusader is also explained, even though that office is not an actual signatory of the MOA. This chapter explains who takes orders from whom, who pays whom, and who needs to give approval before certain tasks can be accomplished.

This chapter also explains what will happen if the program falls behind schedule or runs over budget due to problems with the armament. It addresses possible courses of action to be taken if the product TACOM-ARDEC delivers to UDLP is late or defective. Questions relating to payment and liability in the case of program cancellation, or the termination of the Government's contract with UDLP for convenience or default are also addressed.

4. Analysis of the Advantages and Disadvantages of the MOA

This chapter explains the relative advantages and disadvantages of the Crusader arrangement with emphasis on the effects on cost, schedule and performance. The administrative differences, manpower requirements and overall efficiency are also compared.

The relative advantages and disadvantages are examined from the perspectives of OPM-Crusader, UDLP, TACOM-ARDEC and its subordinate labs and arsenals, and the U.S. taxpayer.

This chapter will also highlight some lessons-learned up to this point by the people and organizations involved in the Crusader armament system. The focus will be to explain issues that should be considered prior to writing a contract and MOA along with suggested courses of action.

5. Conclusions and Recommendations

This chapter will present a clear and concise summary of the conclusions that can be drawn from the research. Recommendations will be made for the Crusader program, and the handling of equipment designed and manufactured by Government agencies in future programs. Additionally, this chapter will present suggestions of areas for further research.

G. BENEFITS OF THE STUDY

This research should provide information that acquisition managers can use to determine how to best manage services and equipment provided by Government agencies in their programs. With the current emphasis on acquisition reform, GFP will come under increasing scrutiny. Relationships such as the one between UDLP and TACOM-ARDEC have the potential to lower costs, decrease administrative burdens, and lower technical risk. This research will help Program Mangers decide if and how best to employ this type of innovative acquisition strategy.

II. BACKGROUND

A. PURPOSE

This chapter provides an account of how cannons were traditionally designed by Government agencies and provided as Government-Furnished Material (GFM) to contractors for inclusion in the construction of tanks and artillery systems. The Government's role in cannon design and manufacturing from the Revolutionary War through the World Wars is outlined for historical perspective. Diagrams of the organizations currently involved in cannon design and manufacture are also provided.

The GFM operations for the M1 "Abrams" series tank and the M109A6 "Paladin" howitzer (the platform that Crusader will replace) are discussed. The associated problems in coordinating, delivering and accounting for the GFM will be examined, along with the associated costs and administrative requirements.

The use of GFM is examined in light of acquisition reform. The underlying reasons for the decision to avoid the use of Government-Furnished Property (including design services and GFM cannons) on the Crusader program are laid out. Also addressed are the anticipated benefits in efficiency and cost savings resulting from the "no GFP" decision.

Finally, the relationships of the agencies involved in the Crusader armament design program are diagrammed. A diagram of the traditional GFM cannon design relationships is also provided for comparison.

B. A HISTORY OF GOVERNMENT'S ROLE IN PROCURING CANNONS

1. The Revolutionary War

In 1775 the Congress procured the first artillery pieces manufactured in the United States. They were copies of captured British designs, produced by private iron foundries in New York, Connecticut, and Massachusetts [Ref. 7]. The objective of the Continental Army was to acquire enough artillery to lay siege to the British in Boston. However, there was a distinct lack of cannon-making expertise in the colonies, and output of the foundries was low, and often not suitable for use in the field. The colonists were forced to rely primarily on captured artillery.

Captured artillery pieces were often damaged in battle, and the rigors of combat wore on the American artillery as well. In January 1777, the Government opened the first "laboratories" (equivalent to today's depots) in Philadelphia and Carlisle, Pennsylvania. Their initial role was to make or repair all the components of artillery pieces except the cannon barrels. These laboratories were staffed by Army artificers who made and repaired "ammunition wagons, axletrees, limbers, sponges, rammer heads, powder casks, and tools, to mention but a few." [Ref. 7] Eventually, the Philadelphia laboratory began casting bronze cannon barrels (coveted for their lighter weight over the cheaper cast iron barrels), but overall output of cannon barrels in the colonies remained distressingly low [Ref. 8].

In November 1776, General George Washington had urged Congress to obtain experts in cannon manufacture (and artillery employment) from France or Holland. This

led to what may have been the first consultant in the American defense industry. A Frenchman, Philip Tronson de Coudray was awarded a contract to be the Inspector General of Ordnance and Military Manufactories in late summer of 1777.[Ref. 7]

Coudray drowned while fording the Schuykill River less than three months later, but the precedent had been set. Other Frenchmen were contracted as artificers and sent to a private foundry (later purchased by the Government [Ref. 9]) in Springfield, Massachusetts. The French expertise was helpful, but shortages in manpower and materials kept the colonial foundries from producing enough cannon barrels to support the Army. Throughout the revolution, America remained dependent on cannon barrels captured from the enemy or purchased abroad.[Ref. 7]

2. The Civil War

Procurement of cannon barrels changed little between the end of the American Revolution and the beginning of the Civil War. The Government arsenals switched over to manufacturing primarily small arms. The manufacture of cannon barrels was contracted out to private foundries. These were delivered to Government arsenals in Washington, District of Columbia; Pittsburgh, Pennsylvania; and Watervliet, New York who manufactured the gun carriages and produced the finished artillery pieces. [Ref. 9]

In 1811, Secretary of War Henry Dearborn tried to get funding for a Government foundry.

> In an attempt to assure a more reliable source of cannons, Dearborn tried to persuade Henry Foxall of the Columbia Foundry to build a new foundry at his own expense on Government land near Washington. Knowing that relying solely on Government contracts, as Dearborn

> proposed, would be risky, Foxall suggested that the Government construct its own foundry, which, like the national foundries for small arms, would encourage uniformity of design and caliber and constitute an extra source of production in case of an emergency.[Ref. 7]

Congress disapproved the request when a congressional study determined that the 530 private foundries operating in America could meet the country's wartime artillery needs. [Ref. 7]

The successes of European rifled artillery were well known by 1846, but the American Army thought that procuring new rifled cannons would be too costly. Colonel James of the Rhode Island Militia, convinced the Army to have rifling cut into the barrels of existing smoothbore muzzle loaders to save money. In 1860, the ordnance department recalled half of the bronze smoothbore cannons in the inventory to rifle their barrels. [Ref. 7] These were provided as Government-Furnished Property[3] to the Ames Manufacturing Company, Chicopee, Massachusetts, which performed the rifling. [Ref. 10] The upgraded weapons, called "James Rifles," saw action in the early years of the Civil War.

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[3] Government-Furnished Property was used for the first time in 1798. Tailors in the Philadelphia area had been delinquent in delivery of uniforms for the Army. The delays had been attributed to difficulties in finding sufficient quantities of the specified cloth. A purveyor for the Army quartermaster corps began to purchase bulk quantities of cloth for the Government. This cloth was then furnished to tailors who were contracted to make the uniforms. This practice ensured that uniforms from different contracts were made with identical material. It also had the potential to reduce costs, since the Government could obtain quantity discounts on cloth that no individual tailor could afford. [Ref. 11: p. 123]

In the years preceding the Civil War, Army officers conducted field artillery research and experimentation. Ordnance Captain Thomas Rodman developed a technique of casting smoothbore cannons over a water-cooled core to increase strength. [Ref.10] These "Rodman Guns" (a.k.a. columbiads) were used extensively during the Civil War, particularly in seacoast defense. The Rodman cooled casting technique was also applied to the manufacture of other types of cannons.

There was one Government-owned foundry which also contributed to artillery research and development. Located at Cold Springs, New York (across the Hudson River from the United States Military Academy), the West Point Foundry had been established to instruct cadets in the principles of metallurgy. Although not established principally to cast cannons, the West Point Foundry had made some rifled cannons prior to 1850 [Ref. 8]. In 1861, Captain Robert Parrott, then superintendent of the foundry, patented a technique of wrapping wrought iron bands around the breech of cast iron guns [Ref. 10]. This allowed cheap cast iron guns to fire the same high charges as the more expensive bronze and harder to manufacture steel guns. Parrott Rifles were mass produced (mostly by private foundries) and used extensively during the Civil War.

The vast quantities of artillery pieces needed for the Civil War exceeded the capacity of the Government arsenals. Private companies were contracted to produce both cannon barrels (for the arsenals) and finished artillery pieces. The Government arsenals assembled finished artillery pieces using contractor-furnished barrels (and the small output of the West Point Foundry) along with other components manufactured at the arsenals. Government arsenals also produced the majority of artillery ammunition.

After the Civil War, the Government began to undertake both the design and manufacture of artillery pieces without the help of industry. In 1878, Colonel Steven V. Benet, Chief of Ordnance, had civil war era muzzle loading cannons converted to breech loaders. Not satisfied with this conversion of a wrought iron gun, Colonel Benet directed a Government arsenal in Watertown, Massachusetts, and the West Point Foundry to produce all steel breechloaders. These new guns were designated the M1885, but only 100 were produced and put in service. A smokeless powder variant, the M1897 was designed and manufactured at the Watervliet arsenal in the late 1890s, but only 110 of these were produced. The turn of the century found the United States with only 210 modern steel howitzers.

In 1898, Captain Charles B. Wheeler designed the first American artillery piece with a recoil system and utilizing brass cased ammunition. Although it was an improvement, the recoil system was found lacking, and the gun had to be re-laid (aimed) after each round. In 1902, the Ordnance Department incorporated some elements of the long recoiling German Ehrhardt gun into Wheeler's design. The result was the M1902 3-inch field gun. Over the next five years, Government engineers in the Ordnance Department designed and type classified four more howitzers of various calibers, but lack of congressional funding prevented them from producing enough modern guns to match the European powers.

3. World War I

The onset of World War I revealed the pitfalls of relying solely on the Government to design and manufacture howitzers. The United States needed to procure large quantities of artillery to equip the forming Allied Expeditionary Force (AEF). It was decided to adopt the French 75mm shell as the standard for direct support artillery because of the abundance of that type of ammunition in theater. Rather than to simply buy modern French and British guns of that caliber, the War Department (at the urgings of the Ordnance Department) attempted to develop two new howitzers.

The first new howitzer, designated the M1916, was an M1902 variant modified to fire the French 75mm ammunition and fitted with a new carriage. The design was not as successful as hoped. "The War Department signed contracts with American manufacturers in 1917. Field tests in December 1917, nevertheless, revealed that the M1916 was inaccurate and that its carriage would break down after hard service." [Ref. 7] Subsequent design changes and frequent defects prevented the M1916 from being produced in quantity.

The other program took a non-developmental approach. Bethlehem Steel Corporation was contracted to produce the British 18-pounder, designated the M1917 by the U.S. Army Ordnance Department. Later, it was decided to modify the British design to fire the same French 75mm ammunition planned for use in the M1916. Incorporating the changes into the foreign design was more difficult than expected, and subsequent quality problems prevented this gun from being produced in quantity as well.

Finally, perhaps in desperation, the Ordnance Department began a program to manufacture the French 75mm howitzer itself in the United States. Although they initially promised support, the French were slow in handing over the technical data package for the gun. The French designs also used the metric system which was alien to most American shops. Additionally, the French design templates were incomplete by American standards. The French used an artisan (craft) production system where an engineer oversaw the product from start to end and could incorporate small adjustments where necessary. The Americans, on the other hand, utilized mass production techniques where an engineer may only see one small component of the finished product. The exacting tolerances that the Americans relied on for mass production efficiency were not present in the French design package. The retooling of American factories also took time. As a result, only 109 French 75s were produced in the United States during the war.

The failure of the Ordnance Department to design and produce sufficient artillery pieces forced the War Department to buy most of its guns from the French and British to equip the AEF. Indeed, when the U.S. Army opened its Saint-Mihiel attack on September 12, 1918, it had 3,010 artillery pieces, but none of them were of American manufacture. [Ref. 9] Government arsenals did not have the capacity to produce the required number of pieces, and American companies did not have the experience necessary to build modern howitzers. General Snow, Commandant of the Artillery School of Fire at the time wrote, "It may be said, then, that we could not and did not equip our Army with artillery during the War."

When the war began the Ordnance Department did not have enough qualified engineers to design cannons, or to advise the private sector on producing them in quantity. Writing about the procurement problems facing America at the start of the war, Benedict Crowell wrote:

> It will be noted that the most important articles in this range are articles of a noncommercial type. In other words, they are not the sort of things that the industry of the country builds in time of peace nor learns how to build....The declaration of war found an American Ordnance Department whose entire commissioned personnel consisted of 97 officers. Only 10 of this number were experienced in the design of artillery weapons....The best it could do was to go into the heavy manufacturing industry for expert engineers who could later be trained in the special problems of ordnance. [Ref. 12]

Before the war's end, America's Government arsenals and industry did manage to produce cannons of several calibers. Virtually all were of modified European designs. Complete howitzers were made at Watervliet Arsenal, as well as by private companies such as the Northwestern Ordnance Company and Bethlehem Steel. Other companies manufactured parts and forgings that were assembled into finished howitzers at Aberdeen Proving Ground and Watervliet Arsenal. [Ref. 12]

Even after the problems of converting European designs to American production techniques were solved, American industry and the Ordnance Department struggled to overcome a shortage of production tooling.

> With practically all of the manufacturers of the American metal-working industries clamoring for machine tools, and with some branches of the Government commandeering the machine-tool shops in whole sections of the country, it is evident that the necessity for the heavier types of machine tools required by the manufacturers of artillery material offered a weighty problem at the outset. In fact, the machine-tool supply was never adequate at any time, and the shortage of this machinery

> hampered and impeded to a great degree the speed of our artillery production. [Ref. 12]

This difficulty in acquiring adequate machine tooling from the peacetime production base to support wartime production had a major influence in the way the War Department prepared for World War II. Indeed, the practice of providing GFP to defense contractors that began prior to World War II may in a large part be attributed to the production problems faced during World War I.

In the years following the Great War, money for artillery modernization was in short supply, and most Army units were equipped with World War I era howitzers through the 1930s. Some new artillery was developed; notably the M2 105mm howitzer, based on a German design. Limited defense funds prevented these designs from being produced in quantity. This lack of money also drove the private companies that made artillery pieces in World War I off to other businesses and re-instituted the practice of relying solely on the arsenals.

> By the 1930s a well-developed arsenal system for field artillery existed. Watervliet, New York, produced finished guns. Watertown, Massachusetts, made gun castings, carriages, and recoil mechanisms for seacoast and antiaircraft guns. Frankfort. Kentucky, supplied fire control instruments, and Rock Island, Illinois, made carriages and recoil mechanisms. These arsenals constituted a ready source for field artillery, but they could furnish only a small fraction of the Army's demands during time of war. This meant that the War Department would have to rely on private industry that had neither the expertise nor experience constructing artillery. [Ref. 7]

Yet, the lessons of the Great War had not been forgotten by the Army. A succession of Ordnance Chiefs from 1916 through 1925 tried to give private companies

contracts to make cannons, but Congress would only allow it if they could beat the arsenals on price. [Ref. 13] Given the high cost of tooling necessary to enter into this type of production, and the arsenals' low overhead rates, this was tantamount to denial.

4. World War II

The National Defense Act of 1916 in theory permitted the Government to buy special tooling for manufacturers willing to take on defense contracts. In practice, this was at odds with the various regulations that dictated contract awards be based on lowest price. Under the looming threat of another war, Congress passed the Ordnance Protective Mobilization Plan of 1939 which allowed the Ordnance Department to give small "education" contracts to manufacturers in order to broaden the production base. These education contracts gave commercial firms the opportunity to produce small quantities of cannons in order to learn the nuances of that unique type of manufacturing. The Ordnance Protective Mobilization Plan of 1939 was the first definite move toward industrial mobilization for World War II.

Once private companies got the contracts, the Arsenals played key roles in helping them achieve a production capability.

> After business firms signed contracts to produce artillery items they sent their engineers and master mechanics to arsenal shops and drafting rooms to learn all they could about tool design, gages, specifications, and requirements for material. "They all go to Watertown and Watervliet," General Wesson reported at a conference. "They are just overrun with these fellows." The arsenals were able not only to provide specifications but also to advise on tool design and requirements for machinery, and to make gages available for study. When manufacturers ran into trouble with specific processes they could call upon the arsenals to send out trained experts to give help. In one instance a Picatinny expert on

> automatic drilling machines was lent to an Ordnance contractor for three months to help install new equipment and to train company employees in its operation and upkeep. Fundamental knowledge of the gun-making art, carefully preserved and nurtured at the arsenals during the inter-war years, was thus quickly passed on to industry at the very start of the rearmament effort. [Ref. 14]

Foreign orders for artillery, particularly from Great Britain, also helped industry prepare for cannon production prior to America's entry into the war. By 1942, America was producing over 43,000 Tank and Artillery cannons a year. [Ref. 14]

The design and development of new artillery systems remained the responsibility of the Government. Typically, the arsenals would design the piece, and then give the technical data package to industry for production while producing some quantity themselves. This was expedient, but did not always result in the innovations that competition can bring. Describing the origins of America's first self propelled howitzer, the M7 "Priest," Boyd Dastrup wrote, "Without the benefit of a solid research and development program, the Ordnance department did nothing more than weld an M2 105mm howitzer to a medium tank chassis and send that weapon to the field." [Ref. 7]

The use of Government-Furnished Property in military contracts became common during World War II. This was common in artillery production where fire control instruments made by one manufacturer were provided to another that produced finished howitzers. Additionally, the Government-owned, contractor-operated (GOCO) arrangement, typically used for ammunition production, was twice used for the production of cannon barrels. [Ref. 14]

Although the use of GFP was vital to the war effort, the disadvantages inherent to GFP also became apparent. The typical problems included difficulties in accounting for Government-owned tooling, dealing with problems when the GFP was delivered late or in the wrong configuration, and the daunting administrative burden on the Government to track the GFP.

Despite these difficulties, the use of GFP was often justified by the prohibitive cost of tooling necessary for defense production, and the expected (if not always achieved) cost savings that should have resulted from the economies of scale that only the deep pockets of the Government could afford. Use of Government-Furnished Materials (GFM, a subset of GFP that comprises components of the end item) also helped to insure standardization across a product line that may have had several different end item manufacturers as was typical during World War II.

After World War II, industry again dropped out of the cannon making business, and Watervliet Arsenal was called upon to design and produce all of the artillery and tank cannons that were required for America's Army. Throughout Korea, Vietnam, and the Cold War these cannons were provided as GFM to the contractors that manufactured the howitzers and tanks. This was the method of cannon design, production and delivery that was used most recently on both the M1 series of tanks, and the M109 series of howitzers.

5. The Current Government Structure

Watervliet Arsenal, to include the Arsenal headquarters and the cannon production facilities, falls under the command of the U.S. Army Industrial Operations

Command (IOC). The task of designing these cannons has fallen on Benet Laboratories (Benet Labs), which is a tenant organization at Watervliet Arsenal. Benet Labs falls under the command of the Armaments Research, Development, and Engineering Center, which is itself a component of the U.S. Army Tank-automotive and Armaments Command (TACOM). TACOM is headquartered in Warren Michigan, while the Armaments Research, Development, and Engineering Center (TACOM-ARDEC) is located in Picatinny Arsenal, New Jersey. TACOM-ARDEC's Fire Support Armament Center designs the gun mounts that mate with the cannons designed by Benet Labs.

Both TACOM and IOC are subordinate units of the U.S. Army Materiel Command (AMC). The command relationship is illustrated in Figure 1. The Command Structure that includes both TACOM-ARDEC and OPM-Crusader is shown in Figure 2.

C. GFM CANNONS FOR THE M1 TANK AND THE M109A6 HOWITZER

The two systems that have been most recently fielded using cannons produced at Watervliet and provided to the prime contractors as GFM are the M1 "Abrams" series of tanks and the M109A6 "Paladin" howitzer.

1. The M1 Series of Tanks

The M1 tank, first fielded in the early 1980s, was originally equipped with a 105mm cannon designed by the British and produced under license at Watervliet Arsenal. In the late 1980s, it was proposed that the M1A1 version of the tank should be fitted with a 120mm cannon designed by the German firm Rheinmetal.

ORGANIZATIONS INVOLVED IN CANNON DESIGN AND PRODUCTION

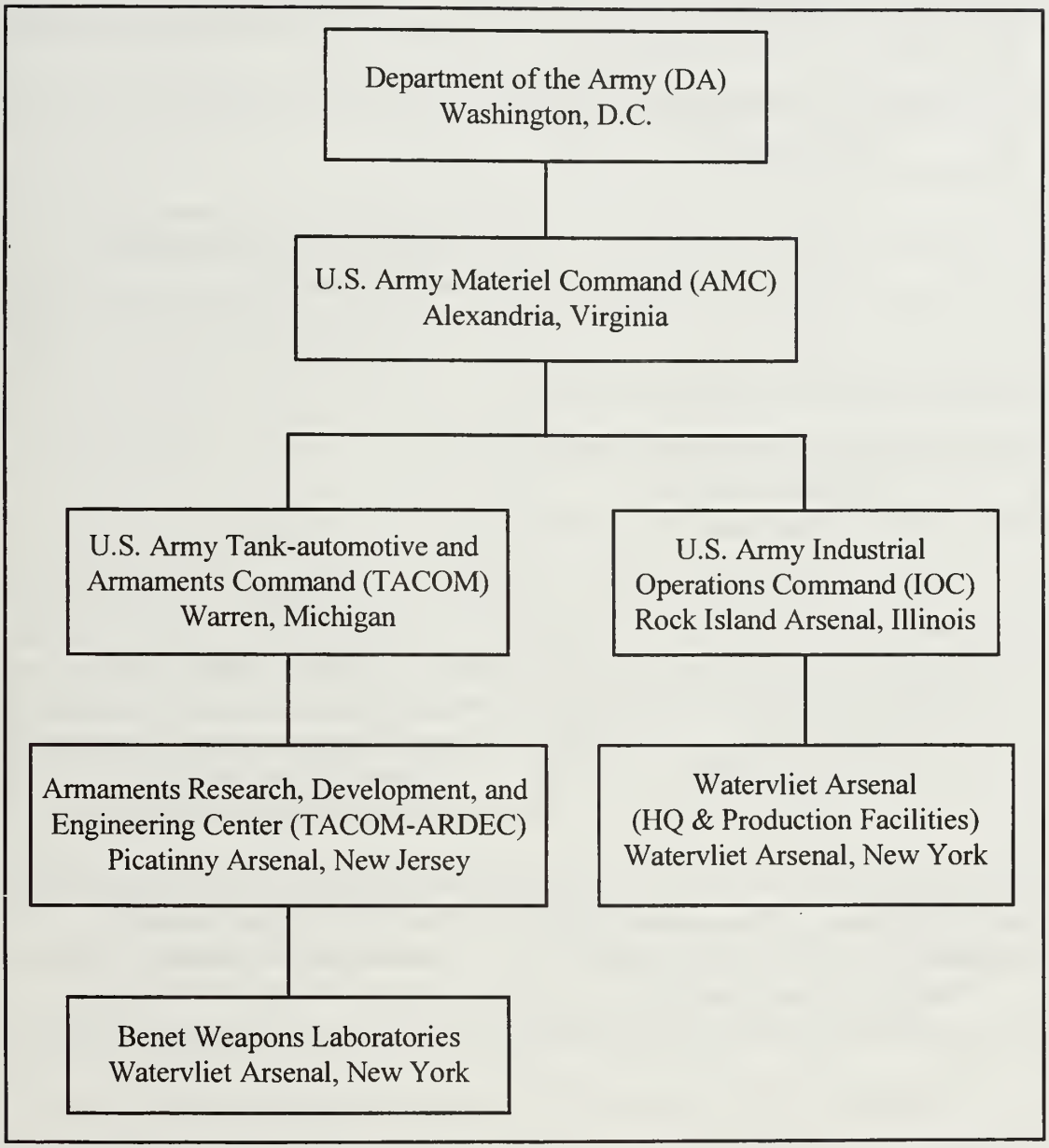


Figure 1. Diagram of the Organizations Involved with Cannon Design and Production. [Ref. 39]

OPM-CRUSADER'S CHAIN OF COMMAND

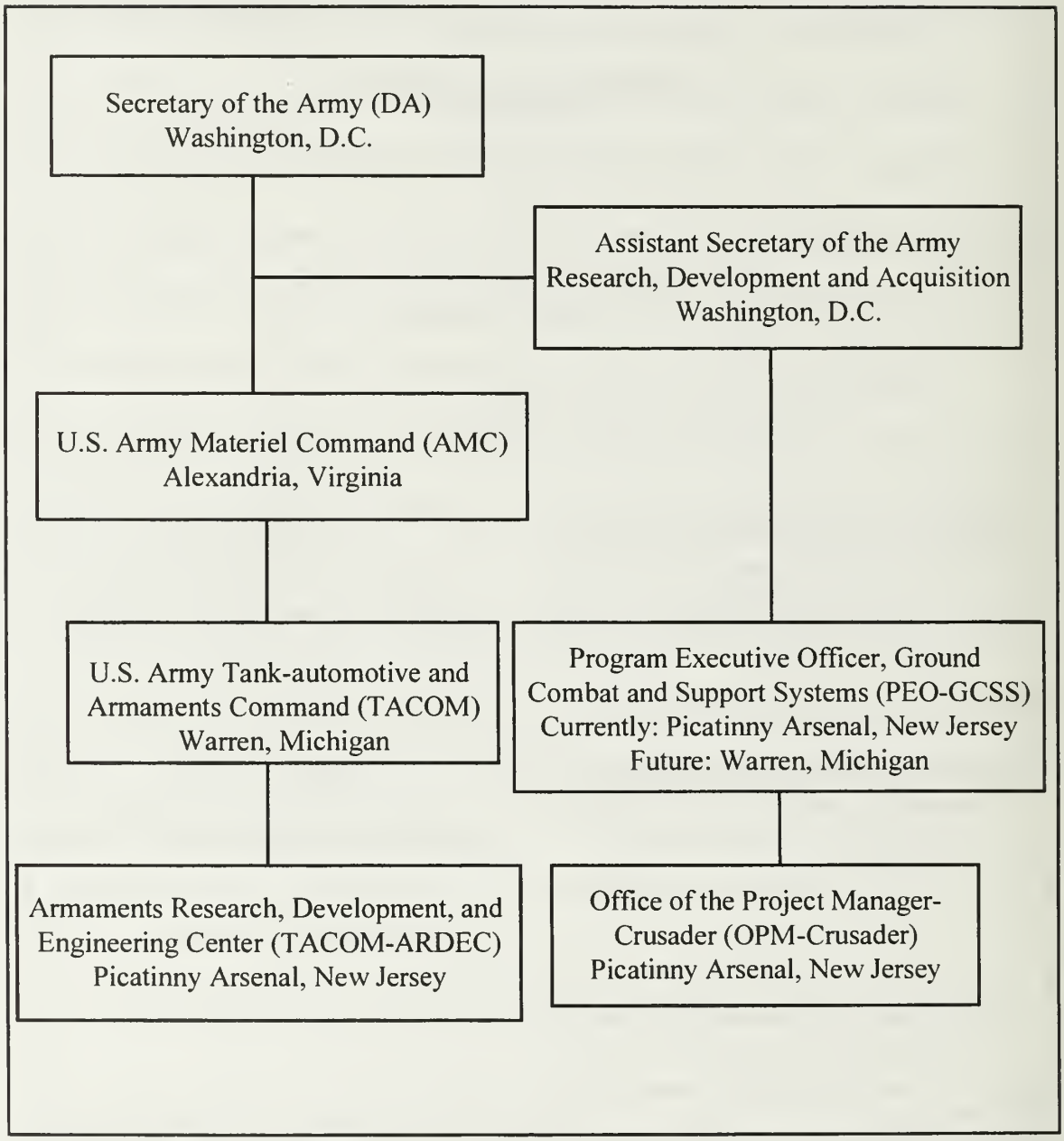


Figure 2. The Command Structure that Includes OPM-Crusader and TACOM-ARDEC. [Ref. 39]

The pros and cons of the Rheinmetal cannon were fiercely debated in the Army and in Congress. Supporters of this initiative in Congress hoped that using the German design would encourage Germany to reciprocate by buying some American weapons, specifically AWACS aircraft. A few Army officers pointed out that the bigger German gun was more lethal than 105mm, even when the latter used advanced American ammunition.

Those opposed to the Rheinmetal cannon (including most Army officers and civilian engineers) maintained that despite the larger caliber, it was only slightly more lethal than the American gun, and both cannons were more than adequate to defeat the Soviet tanks fielded at the time. They also pointed out that when the next generation of Soviet tanks was fielded, there was no guarantee that either gun would be good enough. A still bigger (and implicitly American designed) cannon might then be needed. The detractors also pointed out that moving to the bulkier 120mm ammunition would lessen the number of rounds that could be carried in the tank.

Eventually the German gun was chosen, and America bought the German technical data package. TACOM-ARDEC and Benet Labs conducted the technology transfer, and modified the cannon to use a U.S. concentric gun mount. [Ref. 15] They also modified the chrome plating in the barrel [Ref. 15] and made minor changes to meet U.S. Army safety standards.[Ref. 16: p. 200] The cannons were then produced at Watervliet Arsenal, and provided to the prime contractor, General Dynamics, as GFM.

2. The M109A6 Paladin Program

The M109 series of 155mm self-propelled howitzers was first introduced in the 1960s, and has been upgraded several times over the years. The M109A2 and M109A3 variants were used for most of the cold war as well as for Desert Storm. The M109A5 has completed fielding to the National Guard, and the M109A6 "Paladin" is currently being fielded to the active Army.

Benet Laboratories began designing the M284 cannon for the M109A5 and M109A6 Paladin howitzers in February of 1985. The Office of the Program Manager-Howitzer Improvement Program (OPM-HIP, later OPM-Paladin) managed the development effort. OPM-HIP also resolved any configuration conflicts that arose between TACOM-ARDEC and the prime contractor, BMY Corporation. OPM-HIP devoted one GS-14 Government Engineer to managing the development and integration of the M284 cannon. [Ref. 17]

To resolve these issues, OPM-HIP convened meetings with TACOM-ARDEC and BMY corporation every two or three months. [Ref. 17] Configuration issues were solved in a sound manner from an engineering point of view, but an earned value approach was not necessarily used.

Early in the Paladin program (the outgrowth of the HIP program), changes were incorporated into the M109 turret that would enable it to accept a longer barreled (up to 52 calibers long) cannon that might eventually replace the M284. The OPM-Paladin supervised the development efforts of both UDLP and Benet Labs to accommodate the

long cannon. Although the 52 caliber length cannon development was eventually dropped, OPM-Paladin had again served as the development manager and integrator.

In the late 1980s, the defense divisions of BMY Corporation and FMC Corporation formed United Defense Limited Partnership (UDLP). UDLP is the prime contractor for the M109A6 Paladin. The M284 cannons are manufactured at Watervliet Arsenal and are being provided to UDLP's Paladin Production Division (UDLP-PPD) as GFM.

3. Problems Associated with GFM

Providing cannons as GFM to contractors results in several costs or potential costs to the Government. These include the direct costs of Government personnel who must manage development, resolve configuration conflicts, and coordinate the timely delivery of GFM. Solving configuration issues without strict regard to earned value also results in additional costs that are more difficult to track. Late delivery of GFM, or delivery of GFM in a defective condition, can give the contractor the right to seek an equitable adjustment (price increase) in his contract. To avoid late delivery, the Government often produces GFM well in advance, which also results in additional costs.

The direct costs of Government personnel involved in managing GFM vary from program to program, but they can be quite high. A 1985 study of GFM estimated the workload associated with GFM in the M1A1 tank program at 7.9 man-years [Ref. 18]. The salaries, as well as indirect costs such as overhead, and eventual retirement benefits

of the Government workers all contribute to the cost of GFM. Direct costs such as salaries are often tracked and considered in GFM decisions, but indirect costs seldom are.

Government contractors are required by law to use Cost/Schedule Control Systems Criteria (C/SCSC) or, more recently, Earned Value Management Systems (EVMS). These methods motivate the contractor to resolve design, engineering, and configuration management issues in the most cost effective manner. EVMS also requires monthly reporting of cost and schedule variances to the planned budget. Government organizations such as TACOM-ARDEC are not typically required to adhere to these EVMS standards. Decisions made by Government engineers and managers, while effective and not intentionally wasteful, do not necessarily consider the best value to the taxpayer. The cost of foregone savings that would have been achieved if Government agencies such as TACOM-ARDEC and Benet Labs used EVMS was not considered in any of the GFM decisions encountered in a review of the literature.

If GFM is delivered late, the contractor has the right to seek an equitable adjustment to his contract under clause 52.245-5—Government-Furnished Property (Cost-Reimbursement, Time-and-Material, or Labor-Hour Contracts) of the Federal Acquisition Regulation (FAR). This can result in a significant increase in the cost of the contract. To avoid the possibility of providing late GFM, the Government sometimes produces the GFM well in advance, and then stores it in depots [Ref. 19]. This avoids late delivery, but incurs additional storage, inventory, and inspection costs.

Another cost of producing GFM early is not so readily apparent, but nevertheless a burden to the taxpayer. By producing GFM early, tax dollars are spent on material

before it is needed to support production. Since our Government operates in a deficit, it must sell debt (in the form of Treasury bonds) to finance the production of GFM. While the GFM is sitting in a depot, the Government is paying interest (bond payments) while receiving no return in the form of increased readiness.

D. THE CRUSADER PROGRAM, GFM, AND ACQUISITION REFORM

The Crusader howitzer program, currently in the Program Definition and Risk Reduction (PDRR) Phase, has avoided the use of GFM and associated Government design services in the cannon system, and instead has fostered a unique teaming arrangement between the prime contractor (UDLP) and TACOM-ARDEC. TACOM-ARDEC signed a Memorandum of Agreement (MOA) with UDLP wherein TACOM-ARDEC would provide engineering services and a technical data package for the development of the Crusader cannon and gun mount. This arrangement takes advantage of Benet Labs' expertise in cannon design and Picatinny Arsenal's expertise in gun mount design, while avoiding many of the costs associated with GFM. This arrangement also supports acquisition reform principles outlined in Department of Defense Directive (DoDD) 5000.1, "Defense Acquisition."

As a defense contractor, UDLP is required to use an Earned Value Management System. Any subcontractors that UDLP hires are also required to use Earned Value Management. Because the MOA makes UDLP the manager of TACOM-ARDEC for this development effort, TACOM-ARDEC is now forced to use Earned Value Management as well. Financial representatives from UDLP work with the cost account managers at

TACOM-ARDEC to track the budget of the development effort and submit the required reports.

Because of the MOA, UDLP can no longer seek equitable adjustment if the design package that TACOM-ARDEC develops is late or defective. Because UDLP is managing TACOM-ARDEC's design efforts, UDLP is responsible for timely delivery. This avoids a potentially costly liability to the Government.

Along with avoiding the costs associated with GFM, the Crusader program should realize additional benefits in terms of efficiency by giving the prime contractor total system responsibility. In the Crusader program, OPM-Crusader, UDLP and TACOM-ARDEC all have members on the Integrated Product Team (IPT) in charge of armament development, but UDLP has management authority over TACOM-ARDEC. UDLP is responsible for resolving configuration conflicts and giving management direction to TACOM-ARDEC. UDLP engineers work with Government Engineers from Picatinny and Watervliet arsenals to help develop the cannon [Ref. 20]. This supports the DoDD 5000.1 principles of using an Integrated Management Framework and Integrated Product and Process Development (IPPD).

The Crusader program also supports another DoDD 5000.1 principle of using innovative practices that reduce cycle time, reduce cost, and encourage teamwork. In the words of Mr. Gilbert Decker, the former Army Acquisition Executive, the Crusader arrangement is "very supportive" of Acquisition reform, and an example of "the way Acquisition Reform ought to happen." [Ref. 21] The Crusader arrangement allows OPM-Crusader to manage the system as a whole, and lets the prime contractor manage the

development and integration of all the sub-systems, to include armament designed and produced by the Government.

A diagram of the Crusader program relationships is included as Figure 3. A diagram of the traditional relationship for developing cannons as GFM is included in Figure 4. Notice how the Crusader relationship allows UDLP and TACOM-ARDEC to resolve configuration conflicts without the involvement of OPM-Crusader. Notice also how the Crusader relationship forces TACOM-ARDEC to utilize an Earned Value Management System (EVMS).

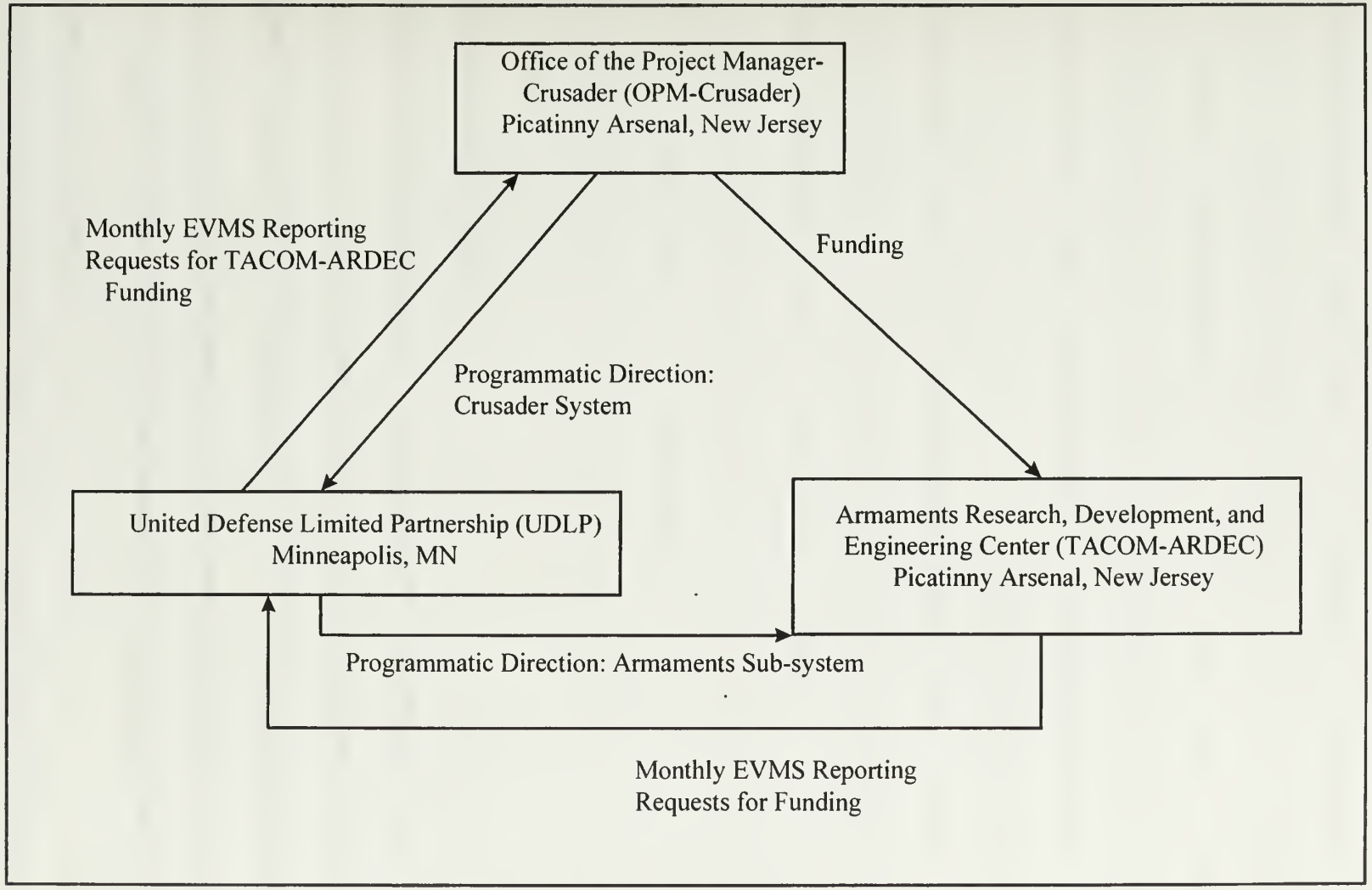


Figure 3. Diagram of the Relationships Between OPM-Crusader, UDLP , and TACOM-ARDEC. [After Ref. 3]

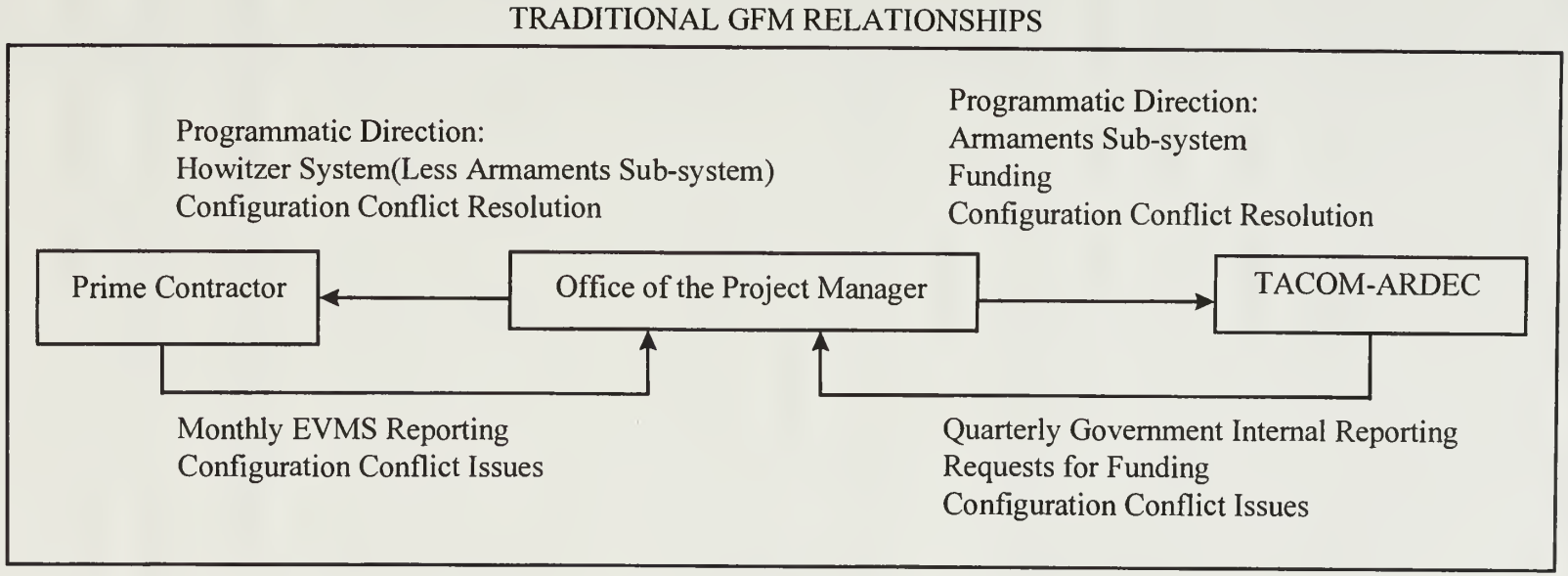


Figure 4. Diagram of Traditional Relationships Between an OPM, prime contractor , and TACOM-ARDEC. [After Ref. 3]

III. DETAILS OF THE MEMORANDUM OF AGREEMENT

A. PURPOSE

This chapter describes the provisions of the Memorandum of Agreement (MOA) between UDLP and TACOM-ARDEC and highlights the key elements. The MOA is included as Appendix B. The working relationships that have developed between UDLP, TACOM-ARDEC and OPM Crusader as a result of the MOA are described in detail. This chapter will explain the lines of programmatic and technical direction authority in the cannon development program. It will also explain the payment and approval process used to fund TACOM-ARDEC's development efforts.

This chapter will also explain what contingencies exist if the program falls behind schedule or runs over budget due to problems with the armament development. It will address possible courses of action to be taken if the products TACOM-ARDEC and its subordinate unit, Benet Laboratories, delivers to UDLP (the technical data package and working prototypes) are late or defective. UDLP's right to unilaterally terminate its relationship with TACOM-ARDEC will be explained. Questions relating to payment and liability in the case of program cancellation, or the termination of the Government's contract with UDLP for convenience or default will also be addressed.

B. DETAILS OF THE MEMORANDUM OF AGREEMENT

The MOA between UDLP and TACOM-ARDEC "sets forth the working relationship ... for the provision of engineering services for the further development of

the Crusader cannon and gun mount and the transition of that technology to United Defense." The MOA covers the design and engineering work to be performed by TACOM-ARDEC in support of UDLP's development of the cannon and gun mount for the Crusader system. The performance period for the MOA and the attached Statement of Work (SOW) is October 4, 1996, through June 30, 2000. [Ref. 22]

The MOA explains the responsibilities of UDLP and TACOM-ARDEC. UDLP's responsibilities include technical and programmatic responsibility for the development effort. This explicitly does not include exercising supervisory control of Governmental employees. However, UDLP will have final say over all technical aspects of the program, including determining the most economical method of fabrication. UDLP is required to provide a technical point of contact who serves in a capacity similar to that of a Government Contracting Officer's Technical Representative (COTR)[Ref. 22]. This technical point of contact is the only person authorized by UDLP to change the scope of TACOM-ARDEC's work effort.

TACOM-ARDEC is responsible for performing to the agreed upon SOW. The MOA directs TACOM-ARDEC to allocate adequate people with the critical skills necessary to perform the work. Additionally, TACOM-ARDEC is responsible for providing office space and support for any UDLP employees that may be required to work in Government buildings at TACOM-ARDEC in Picatinny Arsenal or at Benet Laboratories in Watervliet Arsenal to support the development effort. TACOM-ARDEC is required by the MOA to utilize UDLP's preferred CAD/CAM/CAE software in the development effort, and to provide the cost, schedule and performance information

required by UDLP for periodic reporting to OPM-Crusader. TACOM-ARDEC is also obligated to notify UDLP prior to procuring goods or services, and if a commercial source is required, to allow UDLP to determine the lowest cost vendor.

One of TACOM-ARDEC's more unusual responsibilities in the MOA is to cooperate with any foreign technical experts that UDLP may bring in to evaluate TACOM-ARDEC's performance. This is subject to the considerations of 10 USC 4542 and various security regulations.

The MOA states that, "In the computation of the labor rate for the assigned Government staff, no general and administrative (G&A) costs will be added to the rate computation." It is important to understand that this does not result in an increased cost to the taxpayer, or an increase in UDLP's profit. Since the Crusader development program is under a cost-type contract, TACOM-ARDEC's G&A costs would be borne by the taxpayer whether included as part of TACOM-ARDEC's operating budget (the current situation) or as part of UDLP's reimbursable expenses.

TACOM-ARDEC's G&A costs were not considered when developing the target cost for UDLP's development efforts. Thus, the omission of G&A costs will not result in a higher incentive fee for UDLP in the cost incentive portion of the contract.

Finally, it should be noted that Government organizations such as TACOM-ARDEC do not have the accounting systems in place to determine easily exactly what their G&A costs are. UDLP was also concerned that the G&A costs of TACOM-ARDEC would rise considerably if Picatinny Arsenal or Watervliet Arsenal were to lose some

tenant organizations due to a draw-down. The resulting shrinkage in the cost base would have made TACOM-ARDEC's portion of the fixed expenses rise.

In a similar case, the Industrial Operations Command (IOC) has requested a waiver from 10 USC 4543 for the IOC-run production facilities at Watervliet Arsenal as part of an acquisition reform initiative. Their justification is, "This legislation recognized the economics associated with accepting orders as long as variable costs as a minimum could be recovered. It is prudent to accept work as long as variable costs as a minimum are recovered and (the work) contributes to core skill retention." [Ref. 23]

Under the terms of the MOA, TACOM-ARDEC is responsible for protecting any proprietary information that UDLP may reveal, and to enter into proprietary information agreements with any third parties that may be involved with the development.

Ironically, the MOA makes TACOM-ARDEC responsible for the few pieces of GFP that are involved in this development effort. The howitzer test beds that mount the prototype guns are GFP to UDLP, and UDLP has provided them to TACOM-ARDEC. TACOM-ARDEC, a Government agency, is now responsible for the care, control, and accounting of GFP!

Although the MOA does not give UDLP licensing rights for any new cannon developed, it does state the intent of UDLP to apply for shared rights with the Government. UDLP is, in effect, paying for the development effort, and expects to have all the rights to the end product that they would have if they financed a subcontractor to develop the cannon.

TACOM-ARDEC agrees to use its best efforts to obtain the granting of the license rights as requested by United Defense. United

> Defense, L.P., has requested an exclusive, irrevocable, royalty-free, world-wide license to make, use, and sell the Crusader cannon and gun mount subsystems when it is employed on the Crusader system, the M109 family of vehicles, or any application for which United Defense, L.P., has specifically adapted the Crusader cannon and gun mount subsystems for a foreign military system. In addition, it is the intent of the parties to grant United Defense, L.P., a nonexclusive, irrevocable, world-wide license to make, use, and sell the Crusader cannon and gun mount subsystems for any other application. The United States Government (USG) shall retain the right to use and have used the licensed technology and to make or have made items covered by the licensed technology for its own use . [Ref. 22]

The MOA lays down the mechanics of how TACOM-ARDEC will report cost of work performed to UDLP and how UDLP will report those costs to OPM-Crusader. Although OPM-Crusader is not a signatory to the MOA, it is understood that OPM-Crusader will transfer funding to TACOM-ARDEC in accordance with the amounts that are reported by UDLP.

The MOA also gives UDLP the right to curtail and even terminate TACOM-ARDEC's work effort. Any reduction in scope of the SOW could result in money being diverted by OPM-Crusader from TACOM-ARDEC to UDLP.

C. THE WORKING RELATIONSHIPS

The relationship between UDLP and TACOM-ARDEC is very much like the relationships UDLP has with its subcontractors. UDLP and TACOM-ARDEC negotiated a Statement of Work (SOW) to provide engineering services to UDLP to develop the XM297 cannon for the Crusader. This SOW was appended to the MOA between UDLP and TACOM-ARDEC, and was considered by OPM Crusader in negotiating UDLP's

contract. TACOM-ARDEC receives technical, cost, and programmatic direction from UDLP. TACOM-ARDEC reports cost of work performed, schedule variations, and technical performance achieved back to UDLP. UDLP reports this information to OPM Crusader, and OPM Crusader then transfers funding to TACOM-ARDEC.

OPM-Crusader does not give orders or direction to TACOM-ARDEC. All technical and programmatic direction from OPM-Crusader is given directly to UDLP. UDLP uses this to develop technical and programmatic direction for its internal divisions, subcontractors, and TACOM-ARDEC. OPM-Crusader tracks TACOM-ARDEC's performance in the same manner that they track the performance of UDLP's subcontractors.

OPM-Crusader can contact TACOM-ARDEC directly to request easily obtained information. If OPM-Crusader wants information about the armament system that would require considerable effort to collect, the questions are directed to UDLP rather than TACOM-ARDEC. This prevents TACOM-ARDEC from having to divert resources from their engineering efforts in order to answer questions or collect data. Since UDLP is in effect paying for TACOM-ARDEC's time, it is only fair that UDLP have control over how that time is spent.

The Crusader system is being developed in an Integrated Product and Process Development environment. The Armaments Development Integrated Product Team (IPT) includes members from OPM-Crusader, UDLP and TACOM-ARDEC. This has helped these organizations to develop their working relationship and allows all parties to have visibility to the armaments development.

> OPM-Crusader has overall management responsibility for the Crusader program, including oversight of the performance, schedule and cost elements of the program. However, UDLP is wholly responsible for development of Crusader per the contract....Having said this, OPM-Crusader deals with UDLP regarding overall program performance, schedule, and cost. UDLP, on the other hand, is responsible for dealing with TACOM-ARDEC regarding performance, schedule, cost and delivery issues pertaining to the XM-297 cannon....
>
> In order to avoid any potential situations in which a request from OPM-Crusader to (TACOM-) ARDEC could be construed as a constructive change to the contract with UDLP, such requests are submitted from OPM-Crusader to UDLP. It is then up to UDLP to direct ARDEC to take appropriate action. However, it should be noted that OPM-Crusader and UDLP agree that matters which do not involve a significant effort (e.g., answering a simple question) and are within the scope of the contract can be communicated directly between OPM-Crusader and ARDEC. This is in keeping with the spirit of Crusader's Integrated Product Team (IPT) approach....[Ref. 24]

Other organizations (e.g., TACOM Headquarters and the Army Materiel Command) may make inquiries to TACOM-ARDEC about the cannon development effort. TACOM-ARDEC answers these questions through OPM-Crusader and furnishes a copy of the correspondence to UDLP. [Ref. 25]

OPM-Crusader exercises supervision over UDLP's armaments development efforts in the same way that it exercises supervision over the development of the drive-train, the turret, the computers, and the crew compartment. Daily telephone calls and electronic mail messages, weekly conference calls, and monthly meetings are used to track performance, cost, and schedule.

UDLP exercises technical and programmatic supervision over TACOM-ARDEC via weekly conference calls and two on-site engineering representatives. The two UDLP engineering representatives are located in the Artillery Concepts building at Picatinny

Arsenal along with TACOM-ARDEC's Crusader Armaments Development office. They make frequent trips to Benet Laboratories at Watervliet Arsenal where most of the actual cannon design work is being performed. The engineering representatives report on TACOM-ARDEC's technical progress to UDLP management, but do not get involved with cost issues. UDLP sends financial managers to coordinate with TACOM-ARDEC's cost account managers twice each quarter.

The Government (represented by OPM-Crusader) and UDLP have a Cost-Plus-Incentive-Fee/Award-Fee (CPIF/AF) contract with the incentive fee based on development cost, and the award fee based on system performance and program schedule. To determine the effect of TACOM-ARDEC's work efforts on UDLP's contract, a target cost of TACOM-ARDEC's work had to be determined. UDLP and TACOM-ARDEC negotiated this target cost based on the agreed upon SOW. The Procureming Contracting Officer (PCO) representing OMP-Crusader reviewed this cost and considered it to be reasonable [Ref. 26]. UDLP and the PCO then negotiated a target cost, minimum and maximum incentive fee percentages, and share ratios for all the other work involved in developing the Crusader [Ref. 27].

For the award fee portion of the contract, the target cost of UDLP's other work was added to the target cost of the TACOM-ARDEC work, and this total was used to determine the size of the award fee pool. Some of the award fee criteria are based on the performance of the XM297 cannon and the ability of TACOM-ARDEC to meet schedule objectives. This arrangement motivates UDLP to be attentive in their management of

TACOM-ARDEC. The award fee comprises the majority of the fee that UDLP can collect in this contract.

The incentive fee portion of the contract considers both the target cost of UDLP's other work, as well as TACOM-ARDEC's work effort. The actual cost (in dollars) of TACOM-ARDEC's performance will not be considered when determining UDLP's final incentive fee. Rather, the direct labor hours and material costs incurred will be compared to those reflected in the initial cost estimate to help determine the final incentive fee amount. This protects UDLP from any wage rate increases that may result from Government reductions in force at TACOM-ARDEC which would necessitate replacing junior workers with more senior (and higher paid) workers. In this manner, savings in direct labor hours and material achieved by TACOM-ARDEC will result in an increase in the incentive fee received by UDLP. Similarly, overruns by TACOM-ARDEC will result in a decrease in UDLP's incentive fee.

It should be noted however, that any savings achieved by TACOM-ARDEC will more than offset the increase in UDLP's incentive fee. It should also be noted that any underruns or overruns achieved by TACOM-ARDEC may very well be due to UDLP's management efforts.

UDLP has the prerogative to change TACOM-ARDEC's SOW, either to increase or decrease TACOM-ARDEC's efforts, and even to terminate the relationship. If this is done, the target cost of TACOM-ARDEC's work will be adjusted, and an equitable adjustment will be made in the target cost of UDLP work effort. However, the sum of

these target costs and the incentive fee arrangement will not change without PCO approval.

The target cost for TACOM-ARDEC's work was negotiated before all other costs, but TACOM-ARDEC did not receive that money in one lump sum. OPM-Crusader funds TACOM-ARDEC incrementally as directed by UDLP [Ref. 28]. With this arrangement, UDLP can influence TACOM-ARDEC monetarily, even though they are not paying them directly. Of course, this does not affect the timing or amount of paychecks for Government employees.

D. PROVISIONS FOR DELAYS, DEFECTS, AND TERMINATIONS

In programs that provide GFM, the Government, more specifically the Program Management Office, is responsible to ensure that the GFM is delivered to the contractor on time and in suitable condition. If the GFM is late or defective, the contractor may request an equitable adjustment in price or fee, and be allowed to slip the delivery schedule. This is not the case with the Crusader program. UDLP is accountable for the performance of work done by TACOM-ARDEC. The services that TACOM-ARDEC provides to UDLP, including engineering drawings and prototypes, are not considered Government-Furnished Services or Material. [Ref. 22]

TACOM-ARDEC is working according to a schedule established by UDLP based on the Crusader program schedule established by OPM-Crusader. As stated earlier, some of the award fee criteria in UDLP's contract are contingent upon the timely development of the armament. If TACOM-ARDEC completes certain phases of the development

early, UDLP could be awarded a higher fee. However, if TACOM-ARDEC falls behind schedule, UDLP stands to forego that portion of their award fee. In any case, the failure of TACOM-ARDEC to deliver a working design on time will not constitute late GFM. UDLP is responsible for developing the whole system, including the armament. Late performance by TACOM-ARDEC will not excuse UDLP from their contractual obligations any more than late performance by a subcontractor would.

Because UDLP has total system responsibility, they are responsible to resolve any configuration management problems, including those that are related to the XM297 cannon. In traditional GFM programs, integration meetings between TACOM-ARDEC and prime contractors were held to resolve configuration problems. The contractor usually had to alter his design to accommodate the design of the GFM, regardless of cost. If a configuration was agreed to, and then the delivered GFM did not meet the agreed upon configuration, the GFM was considered defective, and the contractor could request equitable adjustment. In the Crusader program, UDLP can resolve configuration conflicts in the most cost effective manner during development. UDLP may choose to alter their turret design, or they may direct TACOM-ARDEC to alter their cannon design. In any case, if there is a configuration management failure, even one that can be attributed directly to TACOM-ARDEC's work, UDLP is considered responsible and cannot seek equitable adjustment.

If UDLP's contract with the Government is terminated for any reason, OPM-Crusader will transfer funding to TACOM-ARDEC to cover the cost of development work actually performed in accordance with the SOW up until the point of termination.

UDLP is not responsible for any additional costs that TACOM-ARDEC may incur as a result of the termination.

E. CONCLUSION

The MOA sets forth a clear working relationship and gives all parties the latitude they need to accomplish their work. The details of how programmatic direction and money flow are clearly laid out. The MOA is also flexible enough to cover any situations that may turn up in the course of the program.

TACOM-ARDEC cannot legally enter into a contract or accept payment from a company. The MOA between UDLP and TACOM-ARDEC enables Government development and engineering agencies (TACOM-ARDEC and Benet Labs) to support the development of the Crusader armament while at the same time giving one party (UDLP) total system responsibility. By giving the prime contractor total system responsibility, OPM-Crusader has avoided a myriad of coordination problems (and their associated costs), and has lowered the chances of configuration management errors. This should result in a better howitzer system at a lower cost to the taxpayer.

IV. AN ANALYSIS OF THE ADVANTAGES AND DISADVANTAGES OF THE MEMORANDUM OF AGREEMENT

A. PURPOSE

The purpose of this chapter is to list, explain, and analyze all advantages and disadvantages of the relationships established by the Memorandum of Agreement (MOA) between UDLP and TACOM-ARDEC. The traditional relationships that occur when cannons are developed by the Government and provided as Government-Furnished Material (GFM) will be used as a basis for comparison.

The factors considered in the list of advantages and disadvantages include programmatic issues such as performance, integration, and schedule. A multitude of cost factors will be examined including contractor overhead and Government management costs. These costs will be examined with respect to both the program office and the Government as a whole.

The peculiarities of Government contracting regulations, and how they differ from subcontracting in industry will be examined in detail. Specifically, the ability of subcontractors to award second tier subcontracts will be contrasted with the ability of a Government agency to award contracts. This became relevant to the Crusader program when the Federal Acquisition Regulation (FAR) prevented TACOM-ARDEC from awarding a desired contract in a timely manner. As a result, UDLP was forced to award a subcontract instead.

This chapter will also address other factors such as equipment standardization, economies of scale, and sustainment of the industrial base. Finally, the advantage of fewer Government personnel in the program will be examined in light of Acquisition Reform.

B. PROGRAMMATIC ISSUES

OPM-Crusader has overall management responsibility for the Crusader program, including the performance, integration, and schedule elements. UDLP is wholly responsible for the development of the Crusader per the contract, to include development of the armament. In all development efforts, UDLP is responsible for the management of their subcontractors. In the armament's development effort, UDLP is also responsible for managing the efforts of TACOM-ARDEC. [Ref. 24]

In programs that have taken the more traditional approach of developing the armament independently and then providing it as GFM, the Government has been solely responsible for the performance of the cannon. In the Crusader program, UDLP is contractually responsible for the performance of the cannon. TACOM-ARDEC still has a vested interest in the performance of the cannon, as its professional reputation (and implicit job security) is at stake. To ensure the success of the development effort, the two UDLP engineers at Picatinny interact with Government engineers from TACOM-ARDEC and Benet Labs on a daily basis. They can offer a fresh perspective on cannon performance issues, and can also draw on the considerable engineering resources of UDLP, if necessary.

The Crusader arrangement has the advantage of capitalizing on the base of knowledge in cannon design that TACOM-ARDEC (particularly Benet Labs) has developed over the years, while being able to draw on the resources of UDLP as well. By acting as an armaments development team, UDLP and TACOM-ARDEC together should be able to produce a better performing cannon than TACOM-ARDEC could have developed on its own.

In past programs, TACOM-ARDEC and Benet Labs were responsible for integrating all the components of the cannon system (e.g., cannon tube, breech, recoil system), and the prime contractor integrated the cannon system into the rest of the vehicle. In the Crusader program, UDLP is responsible for all integration. This has the advantage of allowing UDLP to make design tradeoffs between the armament and other systems to reduce cost and optimize performance. To give a hypothetical example, UDLP could direct TACOM-ARDEC to modify the design of the recoil system rather than have UDLP's own engineers conduct a more costly or performance reducing modification to the turret.

Achieving this integration was not without its difficulties. Benet Labs was forced to switch from a computer aided design software called Auto-CAD to the Pro-E design software that UDLP is using on the rest of the Crusader development.[4] Interestingly, this did not increase the cost to the Crusader program because UDLP provided Benet Labs with computers and software that the Government had provided to UDLP for previous

[4] TACOM-ARDEC's gun mount design team in the Fire Support Armament Center at Picatinny Arsenal was already using Pro-E software.

programs as GFP. Still, the engineers at Benet Labs did have to devote some time to learning the new computer software.

Because the cannon development schedule milestones impact on the award fee portion of the contract, UDLP is pushing TACOM-ARDEC to stay on schedule. While TACOM-ARDEC always strove to keep on schedule in previous development efforts, UDLP's management efforts have been more rigorous than those that TACOM-ARDEC has experienced in the past. In previous programs, TACOM-ARDEC would update their development schedule quarterly. Under the supervision of UDLP, TACOM-ARDEC is now updating the schedule on a monthly basis. This has increased the administrative and reporting requirements on TACOM-ARDEC, but has also ensured that schedule issues are considered consistently during the development effort.

Although the added administrative reporting requirements on TACOM-ARDEC may be seen as a disadvantage by some, the overall effect on the Crusader program should be positive. The management efforts by UDLP should increase the likelihood that the Crusader armament will be developed on schedule.

The relationship established by the MOA between UDLP and TACOM-ARDEC should result in many programmatic advantages impacting performance, integration, and schedule. Richard Kopmann, TACOM-ARDEC's Deputy Product Manager for Crusader Armaments, summed it up best during an interview with the researcher. Although the administrative and reporting requirements were more than he anticipated when his organization entered into the MOA relationship, he concluded that ultimately OPM-Crusader "will get a better product." [Ref. 25]

C. COST ISSUES

1. Costs Issues of GFM

The most common argument in favor of the Government providing materials and services to contractors is that GFM saves the overhead (burden) rates and profit that a contractor would normally add to the cost of a material or service. When deciding whether or not to provide an item as GFM, the contractor's known burden and profit rates are used. Typically, the contractor's profit and burden rates are applied to the cost of the item, and these added costs are compared to the cost to manage the item as GFM. Too often, however, the only costs of managing GFM that are considered are the direct labor and material costs.

Many of the indirect costs of providing GFM are not traceable to any particular program. Therefore, they are not considered in any individual program's decision of whether or not to provide an item or service as GFM. The costs that GFM incur that are not necessarily traced to the program include matrix support such as legal and administrative services, the facilities capital cost that the Government must incur to accommodate the workers involved in supporting the GFM effort, and the retirement benefits that those Government workers will ultimately receive. The additional infrastructure that is required to support the added Government workers (e.g., bigger cafeterias and daycare centers, more janitorial services, larger parking lots) is never considered in the GFM decision of any particular program. Nevertheless, it is an inescapable fact that adding Government workers (to manage GFM) will add to these

infrastructure costs. The "savings" touted by a particular program in providing GFM may very well be offset by these additional, yet not directly traceable, costs to the Government.

Another pathology common to GFM cost decisions concerns applying the contractor's current burden rates to the item in question, and then comparing that added cost to the cost of providing the item as GFM. Many programs disregard the fact that providing an item as GFM will increase the contractor's burden rate. When a contractor provides an item, the cost of the item is included in the cost base for that burden category. If the same item is provided GFM, the cost base shrinks, and the corresponding burden rate increases. "A reduction in the contractor's total cost base for an individual burden rate may raise the rate, thereby mitigating the effect of the cost reductions." [Ref. 29; p. 9] Because of this, the costs due to the increased burden rates will partially offset any potential savings of providing the item as GFM.

Profit is the one cost that is completely avoided by utilizing GFM. Government agencies do not add a profit percentage when furnishing material and services to Government programs. The profit percentages that contractors charge vary from program to program. In programs that operate under CPIF contracts, the minimum fee is usually very low.

In Award-Fee contracts, the profit rate would have nothing to do with the cost of GFM. Instead, the profit is determined by schedule and performance achievements. Because of this, the cost of UDLP's management efforts over TACOM-ARDEC have no affect on the award fee portion of the Crusader contract.

2. Costs of the Crusader Program

In the incentive fee portion of the Crusader development program the target fee is six percent of target cost at target cost, and the minimum fee is three percent of target cost at a ten percent or greater overrun from target cost [Ref. 30]. In order to increase their profit percentage, UDLP will have to decrease the cost of the program. Any added profit that UDLP receives under the incentive fee portion of the contract will be more than offset by the savings to the Government of the reduced program cost.

Highlighting the armaments development effort in this contract, OPM-Crusader plans on paying a six percent profit on the management costs that UDLP incurs to assume technical and programmatic direction over TACOM-ARDEC. For this modest premium OPM-Crusader has completely avoided all GFM management costs, kept total system responsibility with the contractor, and avoided the potential for contractor claims due to late GFM.

The MOA between UDLP and TACOM-ARDEC has the advantage of reducing the number of people required to support the Crusader program. The Crusader program office does not have to devote anyone to coordinating the work efforts of TACOM-ARDEC. Rather, OPM-Crusader works directly with UDLP and UDLP works directly with ARDEC. Therefore, OPM-Crusader avoids the additional personnel requirements that the program office would have in a traditional GFM arrangement.

The MOA has not increased the personnel requirements at TACOM-ARDEC either. Although the reporting requirements have increased for TACOM-ARDEC and

Benet Labs, they have managed to meet these requirements without increasing the number of personnel. Technical item leaders (Tech Leads) have taken up the additional responsibility of being cost account managers.

3. Costs Savings as a Result of Using Earned Value Management

Earned Value Management Systems (EVMS) utilize 32 guidelines that cover program areas such as organization, planning, accounting, and reporting [Ref. 31; p 1] These guidelines ensure that work is appropriately distributed and integrated among participating organizations. The guidelines also ensure that work is thoroughly planned and scheduled, and a time phased budget baseline (schedule) is established. Finally, EVMS forces the accurate accounting and monthly reporting of incurred costs, and comparison of these incurred costs to the budget baseline. In this way managers can track earned value in terms of both cost and schedule.

As the prime contractor for the Crusader program, UDLP submits monthly reports to OPM-Crusader that compare the costs actually incurred to date to the budget baseline. UDLP includes all the costs of their subcontractors as well as TACOM-ARDEC's costs in these monthly reports. The reporting procedures used for EVMS are more stringent than the reporting procedures TACOM-ARDEC used in past programs when designing cannons to be provided as GFM. Because of this, EVMS gives OPM-Crusader better visibility of the costs that TACOM-ARDEC is incurring in the armaments development effort. This advantage, while difficult to quantify in terms of cost savings, will allow OPM-Crusader to track the program performance against the budget more effectively.

Additionally, through this experience TACOM-ARDEC may become much more proficient in management of project costs.

D. PECULIARITIES OF GOVERNMENT CONTRACTING REGULATIONS: THE WELLHEAD DIVISION CASE

One disadvantage of UDLP's relationship with TACOM-ARDEC is that Government organizations such as TACOM-ARDEC have less flexibility in awarding contracts than the subcontractors that UDLP usually deals with. TACOM-ARDEC must follow the Federal Acquisition Regulation (FAR) and other Government regulations when awarding contracts. Often, these regulations are more concerned with fairness of Government contracting than with efficiency. Government agencies such as TACOM-ARDEC also can not usually award a contract as rapidly as most commercial subcontractors. This had an impact on the Crusader program when TACOM-ARDEC and UDLP decided to contract some work originally planned for Benet Labs to another company.

Preliminary firings by some prototype cannons using a new modular propellant revealed that the breech seal was fouling more rapidly than expected. If not corrected, this problem would force the Crusader crewmen to clean the breech more than once per day during heavy firing. Benet Labs felt that they could redesign the breech seal to relieve the fouling problem, but they thought it was prudent to have other organizations examine the problem as well. Together, the engineers and managers from TACOM-ARDEC and UDLP decided to contract out work on alternate breech seal designs in order

to avoid delays and to mitigate risk to the program. FMC Corporation's (Oil) Wellhead Division was chosen because of its experience in making metal parts seal under hot and dirty conditions. At the time, UDLP was partly owned by FMC Corporation, and Wellhead was one of UDLP's "sister" divisions.

TACOM-ARDEC initially tried to award a contract to Wellhead Division themselves, submitting a request to the Picatinny Arsenal Procuring Contracting Officer (PCO) to award a $204,000 contract for work on breech seal redesign. TACOM-ARDEC tried to avoid a competitive contract award (normally a requirement for Government contracts over $100,000) on the basis of Unusual and Compelling Urgency. Unusual and Compelling Urgency is one of the exceptions to the FAR requirement for full and open competition. The PCO rejected TACOM-ARDEC's argument of Unusual and Compelling Urgency because it did not meet the requirements in FAR Subpart 6.302-2. The PCO directed TACOM-ARDEC to come up with a better justification, or open the contract to all interested parties and award it by competitive means [Ref. 33]. The fact that Wellhead was a sister division of UDLP also gave the appearance of a possible conflict of interest.

TACOM-ARDEC and UDLP were concerned that the development schedule would slip if the work was delayed.[Ref. 25] Engineers from Benet Labs and Wellhead had already talked with each other about the work, and both sides were hopeful that Wellhead could help solve the fouling problem. Engineers on the OPM-Crusader staff also thought that Wellhead Division could make a significant contribution to the project [Ref. 15]. To avoid further delays due to Government procurement regulations, UDLP

decided that it would contract with Wellhead Division directly, and transfer the money devoted to that work package from TACOM-ARDEC's portion of the Crusader development contract to UDLP's portion.

Wellhead Division was given the work by UDLP, and they made significant design contributions to solving the fouling problem. Engineers from Benet Labs and TACOM-ARDEC learned about alloys and other material science issues that Wellhead division used on oil rig seals. In turn, Wellhead Division engineers learned about physical design characteristics that Benet Labs incorporated in cannon breech seals. Both groups of engineers learned things that they could apply to the Crusader program and future development efforts. Mike Hermanson, one of UDLP's engineers at Picatinny, remarked "There was no fear of future competition between Benet Labs and Wellhead Division. Both sides know that Wellhead would never go into the cannon design business, and Benet Labs would never start making oil rigs. This resulted in a free flow of information between the groups of engineers."[Ref. 34]

Although contracting the work to FMC's Wellhead Division was a success from an engineering point of view, it did reveal one problem associated with transferring money from TACOM-ARDEC's portion of the contract to UDLP's portion. When the breech seal work package was originally computed for TACOM-ARDEC, it was calculated at $178,000. In accordance with the MOA, General and Administrative (G&A) costs were not included in that calculation. The labor and material amounts used in Wellhead's proposal were comparable to TACOM-ARDEC's estimate. However,

when Wellhead division performed the work they incurred G&A expenses which brought their total costs to $204,000. This additional cost was considered an overrun by the PCO.

Under the terms of the Crusader development contract, UDLP can transfer money from TACOM-ARDEC's effort to UDLP's effort, but the sum of the two cannot change.[Ref. 28: para. H.20.9] This meant that UDLP could only transfer $178,000 from the TACOM-ARDEC portion to the UDLP portion. UDLP had to absorb (as an overrun from target cost) the additional $26,000 that was required to pay Wellhead Division. This unplanned $26,000 expense will make it harder for UDLP to achieve their target cost under the CPIF portion of the contract, and may serve to lower their profit.

The PCO did give UDLP the option of transferring all $204,000 from the TACOM-ARDEC portion of the contract,[Ref. 33] but the UDLP managers were afraid that that would leave the remaining TACOM-ARDEC work under-funded [Ref. 35]. The work packages for TACOM-ARDEC had been carefully developed, and removing an additional $26,000 from TACOM-ARDEC's budget could only have been done at the expense of other remaining work packages.

It is ironic that during negotiations over the MOA, UDLP pushed for the removal of G&A expenses from TACOM-ARDEC's costs. UDLP did this to limit their risk of cost increases if TACOM-ARDEC's G&A expenses were to rise due to a Government draw-down [Ref. 36]. However, by removing G&A expenses from the work packages, UDLP has, in effect, agreed to absorb the G&A expenses of any work later transferred from the TACOM-ARDEC portion of the contract to the UDLP portion. Whether they realized it during negotiations over the MOA, UDLP had the choice of including

TACOM-ARDEC's G&A expenses and accepting the risk that they would later rise, or excluding the G&A expenses and accepting the risk that UDLP would have to absorb the G&A expenses of work later transferred from TACOM-ARDEC.

The Wellhead Division episode is an example of some of the disadvantages that prime contractors such as UDLP face when entering into an agreement like the MOA. The inflexibility of Government contracting regulations, and the uncertainties of how to best deal with Government G&A expenses make the Government a less than perfect business partner.

E. OTHER ADVANTAGES AND DISADVANTAGES

1. Equipment Standardization

One common argument in favor of providing GFM is that it will ensure standardization of equipment across product lines. An example would be a gage provided as GFM to a multitude of vehicle manufacturing programs. Use of this single type of gage would reduce the spare parts inventory that would be required if each type of truck used a different type of gage.

In the Crusader program, standardization has not been sacrificed. Under the terms of the MOA, "the USG (Government) shall retain the right to use and have used the licensed technology and to make or have made items covered by the technology for its own use." If the United States were to undergo a large mobilization, this clause ensures that the Government could both produce and contract other firms to produce the Crusader

armament to support the war effort. These would have complete standardization with the cannons made for UDLP.

2. Economies of Scale

Another common argument in providing GFM is that the Government can purchase huge quantities of items that no individual firm could afford. The associated quantity discount can result in savings to the taxpayer. In the gage example above, the large quantities of gages to be procured would give the Government tremendous leverage at the bargaining table. They could secure a price far lower than any individual program's procurement could reach.

In the Crusader program, the economies of scale argument is not so easily applied. The engineering services provided by TACOM-ARDEC, and the subsequent cannons made (most likely) by Watervliet will be used to support only the Crusader program and UDLP. In the event of a large mobilization, if M297 cannons were needed for a number of systems besides Crusader, or for contractors in addition to UDLP, then the Government might again explore the feasibility of providing the cannon (or parts thereof) as GFM.

3. Industrial Base

One advantage that the Crusader program has over traditional GFM programs is that it plays a role in expanding the industrial base. UDLP engineers are learning far

more about cannon design and production than they would if the cannon system had been developed as GFM.

The large capital equipment expense of cannon producing machinery will probably prohibit UDLP from manufacturing the M297 cannon for the current Crusader program. However, if a mobilization forced a requirement for cannon production that exceeded the capacity of Watervliet Arsenal, UDLP would be better prepared than other firms to manufacture the guns. The knowledge that UDLP engineers are acquiring in the course of Crusader development is strengthening America's defense industrial base.

4. Manpower

One last advantage of the Crusader arrangement over traditional GFM relationships is that the Crusader program requires fewer people. Under a traditional GFM relationship, one or two people would be employed full time in the Program Management Office coordinating and tracking GFM. Others would be required (e.g., DCMC) as matrix support. Because UDLP is wholly responsible for the development of the Crusader per the contract, and because UDLP can exercise management over TACOM-ARDEC via the MOA, OPM-Crusader does not need extra people to manage GFM. This supports the Department of Defense's goal of "Right-Sizing the Acquisition Workforce."

In his statement before the House Committee on National Security on February 1997, the Honorable Paul G. Kaminiski said "We forecast that by the end of FY2000, these same (DoD acquisition) organizations will effectively be 48% smaller, or down by

more than 288,000 people. The Department continues on a deliberate consistent reduction path of actively managing our personnel in acquisition organizations." [Ref. 32] As the trend to reduce the Federal acquisition workforce continues, more and more program offices will be forced to adopt an arrangement similar to Crusader's. There may simply not be enough people in Federal Government to execute GFM as it has been traditionally done.

V. CONCLUSIONS AND RECOMMENDATIONS

A. PREFACE

The relationships between OPM-Crusader, UDLP, and TACOM-ARDEC should produce a better designed weapon system at a lower cost than would have been achieved through the traditional GFM armaments design process. The Memorandum of Agreement between UDLP and TACOM-ARDEC provides a robust framework for establishing those relationships.

This chapter will present a summary of the conclusions that can be drawn from the research. Recommendations will be made for the Crusader program, and the handling of equipment designed and manufactured by Government agencies in future programs. Additionally, this chapter will present suggestions of areas for further research.

B. CONCLUSIONS

1. Design Improvements

The relationships in the Crusader Program should result in a better designed howitzer. By giving UDLP total system responsibility, OPM-Crusader has ensured that all design and performance issues will be optimized with regards to the total system. Under the traditional GFM process, the prime contractor would seek to resolve design and performance issues without regard to the armament. At the same time, TACOM-ARDEC would seek to resolve armament issues with little regard to the rest of the

system. Thanks to the relationships established by the MOA, UDLP will keep a total system perspective when resolving conflicts and tradeoffs.

Because of the MOA, Government and industry engineers have a closer working relationship than they would have had under the traditional GFM process. Both groups of engineers work to prevent design conflicts and work toward a better integration of the cannon with the rest of the system. This can result in a synergy that will produce design integration and innovations that would not have occurred if the engineering teams had been working separately.

2. Cost Savings

The relationships fostered by the MOA should result in a lower cost to the Government. The use of an Earned Value Management System (EVMS) by TACOM-ARDEC should itself significantly lower the Government development cost, and assist OPM-Crusader in better tracking the funds spent on development. The detailed monthly reporting will keep TACOM-ARDEC focused on efficiency and cost savings. This is a great improvement over the less detailed reporting that was conducted quarterly under the traditional GFM process.

By avoiding the use of GFM, OPM-Crusader has eliminated all GFM related costs. These costs include additional personnel direct and indirect costs within the OPM-Crusader staff and matrix organizations. OPM-Crusader has also avoided any potential costs that would result from Government liabilities due to late or defective GFM (e.g., the armament technical data package). Also, by insisting that the Government and

industry engineers work together during development, OPM-Crusader has helped to ensure that no unexpected (and hence costly) design conflicts will occur later in the program.

Finally, because UDLP is under a cost incentive type contract that considers both their and TACOM-ARDEC's costs, they are striving to avoid costly integration issues during the development phase. UDLP realizes that they are responsible for TACOM-ARDEC performance in terms of both cost and performance.

> The advantage now is that UDLP can't blame the Government for late or defective GFM. UDLP is working harder to control interfaces because they can no longer blame the Government for configurations issues. If we didn't enter in to this agreement, the taxpayer would have ended up paying more.[Ref. 37]

Avoiding costly rework efforts by getting configuration issues right "the first time" is one more way that the Crusader relationships are saving money.

C. RECOMMENDATIONS

1. Recommendations for the Crusader Program

OPM-Crusader should strive to foster similar agreements between UDLP and other Government organizations that support the Crusader program. These include Government test agencies and agencies that support common equipment (such as radios and computers) that the Crusader system may utilize. Some of these organizations, such as the U.S. Army Test and Evaluation Command (TECOM) can enter into contracts and will not require an MOA. Having TECOM conduct some "contractor" testing may also

foster cooperative relationships that will benefit the program during developmental testing.

OPM-Crusader should also consider keeping total system responsibility with the prime contractor during the production phase of the Crusader program. The U.S. Army Industrial Operations Command, which controls the Watervliet Arsenal production facilities, can accept contracts. By forcing the prime contractor to subcontract directly with IOC for the production cannons, rather than providing the cannons as GFM, OPM-Crusader will again avoid many of the costs inherent to GFM.

2. Recommendations for Other Programs

Other programs should consider the use of a similar MOA or teaming agreement if another Government agency is involved in providing GFM for the program. This will ensure that Government and contractor personnel work together to resolve configuration issues during the design phase of a program. During both the design and production phases of a program an MOA similar to the one between UDLP and TACOM-ARDEC could help avoid many of the costs associated with development, manufacturing, and management of GFM.

Other programs should also consider requiring supporting Government agencies to adopt EVMS. This could apply both to Government design agencies and matrix support organizations. Program management offices may even consider using EVMS within their own organizations! This will give the Program Manager better visibility on how the program budget is being executed.

D. AREAS FOR FURTHER RESEARCH

The following are recommended topics for further research:

1. Application of a Similar MOA to a Weapon System in the Program Definition and Risk Reduction (PDRR) Phase

Both TACOM-ARDEC and the Rocket and Missile Research Development and Engineering Center (in Redstone Arsenal, AL) support various programs in the Program Definition and Risk Reduction (PDRR) phase. It may be appropriate to apply similar teaming arrangements to those programs.

2. Application of a Similar MOA to Any System in the Production and Operational Support Phase

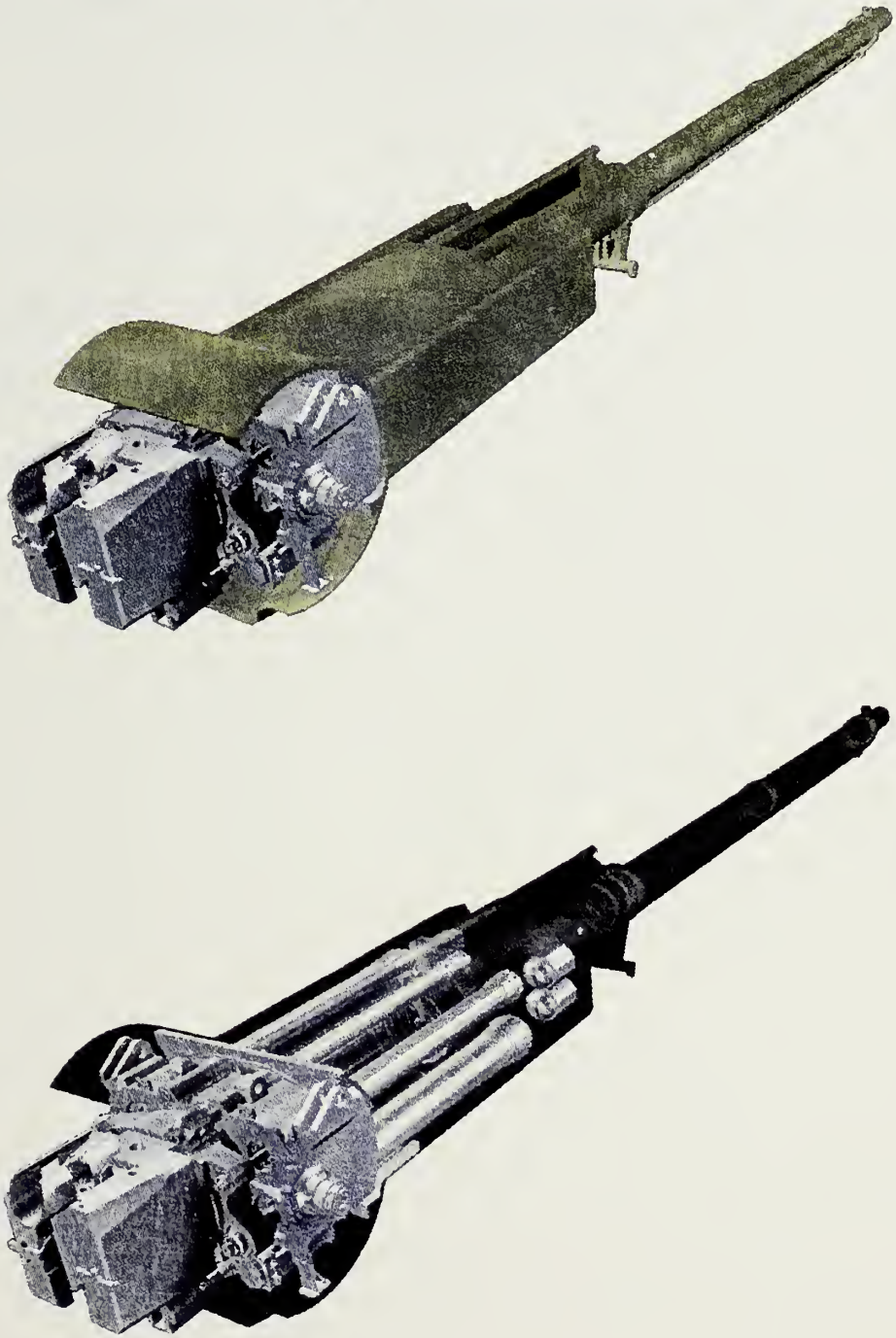
Many programs utilize GFM for the production phase. Other programs provide GFM to contractors with support contracts. While some of the GFM is purchased from commercial firms, other GFM is the product of Government Depots.

One example is the M2A3 Bradley Fighting Vehicle production program. The Red River Army Depot refurbishes older models of Bradley Fighting Vehicles to partially bring them up to the A3 specifications. The vehicles are then provided as GFM to UDLP for the remaining modifications to complete the A3 upgrade. Currently, OPM-Bradley must coordinate the actions of the two agencies. The program management office may be able to reduce duplication of effort and lower costs by having UDLP enter into an MOU or contract directly with Red River Army Depot.

Another example is the support operations for the Air Force F-117 Stealth Fighter program. A Navy depot remanufactures the engines for the aircraft. The rest of the support operations are contracted out to Lockheed Martin Skunkworks. The program management office must coordinate the activities of the two. It is possible that an MOA or contract between Lockheed Martin and the Navy Depot may improve efficiency and reduce costs.

APPENDIX A

IMAGES OF THE CRUSADER ARMAMENT



The Crusader Armament (top) and a cutaway view of the armament showing the XM297 cannon and the XM183 Gun Mount (bottom). [Ref. 38]

APPENDIX B

THE MEMORANDUM OF AGREEMENT

MEMORANDUM OF AGREEMENT BETWEEN UNITED DEFENSE LIMITED PARTNERSHIP AND TACOM-ARDEC

All requests concerning this MOA to include additional copies are to be directed to:

MS. BARBARA J. MACHAK
CHIEF, ARTILLERY CONCEPTS BRANCH
TACOM-ARDEC
(973) 724-2953 DSN 880-2953

MEMORANDUM OF AGREEMENT (MOA)
BETWEEN
UNITED DEFENSE, LIMITED PARTNERSHIP
AND
THE UNITED STATES OF AMERICA
REPRESENTED BY
THE US ARMY TANK-AUTOMOTIVE AND ARMAMENTS COMMAND (TACOM)
ARMAMENT RESEARCH, DEVELOPMENT AND ENGINEERING CENTER (ARDEC)

This Memorandum of Agreement (MOA) is entered into this 6th day of November, 1996, between United Defense, L. P., Armament Systems Division (hereinafter referred to as "United Defense"), 4800 East River Road, Minneapolis, MN 55421-1498, and the United States of America, represented by US Army Armament Research, Development and Engineering Center (hereinafter referred to as "TACOM-ARDEC"), headquartered at Picatinny Arsenal, New Jersey 07806-5000.

United Defense and TACOM-ARDEC have entered into this MOA which sets forth the working relationship between United Defense and TACOM-ARDEC for the provision of engineering services for the further development of the Crusader cannon and gun mount and the transition of that technology to United Defense. The technical work being performed by TACOM-ARDEC is reflected in the attached Statement of Work (SOW). The effort to be performed by TACOM-ARDEC, however, will not be construed as government furnished services under the United Defense development contract (DAAE30-95-C-0009). Any costs associated with United Defense's effort in performance of the MOA or its SOW are included in that contract. TACOM-ARDEC cannot accept a contract from United Defense. The Office of the Project Manager for Crusader (OPM Crusader) will directly fund TACOM-ARDEC for the performance of the MOA SOW. Nothing in this MOA shall be construed to change the terms of the contract. Any inconsistencies between the terms of that contract and this MOA shall be resolved based upon the terms of that contract. This MOA is not considered a part of that contract and there is no intent to include the MOA by reference into that contract.

I. Purpose:

a. The purpose of this MOA is to set forth the working relationship between United Defense and TACOM-ARDEC for the design, engineering development and transition of the advanced solid propellant cannon and gun mount subsystems in support of the Crusader program. This cooperative effort strives to draw upon the strengths of both United Defense and TACOM-ARDEC to achieve a quality product the first time, within budget, and on schedule. The Integrated Product and Process Development (IPPD) environment to be utilized in this development promotes the achievement of mutually beneficial goals of both United Defense and TACOM-ARDEC.

b. For purposes of this MOA:

1. The advanced solid propellant cannon subsystem comprises the tube assembly (including any required integral thermal management), the breech assembly (including actuators), the propelling charge igniter assembly, the bore scavenger assembly, the muzzle brake, and associated sensors.

2. The gun mount subsystem consists of the gun cradle structure and rotor shield, recoil and counter recoil cylinders and replenishers, any required gun mount integral thermal management, and mounting interface for gun pointing sensors.

II. Scope:

This MOA covers the design and engineering work to be performed by TACOM-ARDEC in support of United Defense's development of the Crusader cannon and gun mount subsystems for the Crusader system, its transition from a government product to an industry product, and its industrialization.

Upon the mutual agreement of United Defense and TACOM-ARDEC the scope of this MOA may be modified to include additional engineering and development efforts through the attachment to the MOA of a statement of work and the modification, if required, of appropriate provisions of this MOA.

III. Statement of Work:

The design and engineering work to be provided by TACOM-ARDEC is described in detail in the attached Crusader Cannon and Gun Mount Statement of Work (SOW) and its accompanying referenced documents including the Integrated Master Plan (IMP) and the Integrated Master Schedule (IMS). Provisioning of that effort shall be the basis of the TACOM-ARDEC labor, material and cost estimate. The period of performance for the Crusader Cannon and Gun Mount Statement of Work attached to this MOA is October 4, 1996 through June 30, 2000.

IV. United Defense Responsibilities:

a. United Defense shall assume the technical and programmatic direction responsibility for the Crusader cannon and gun mount subsystems teams upon the effective date of this MOA. Although TACOM-ARDEC employees will be performing the major portion of the development and design effort, they shall take their technical and programmatic direction only from United Defense. Both parties agree that the supervision and control of government employees is an inherently governmental function. Therefore, nothing in this agreement shall be construed as to give United Defense the authority to exercise supervisory control over government employees. If there is a disagreement regarding any technical aspects of the program, United Defense's resolution of the disagreement shall be implemented and considered final.

b. United Defense shall provide the programmatic management and technical direction staff at TACOM-ARDEC that it considers appropriate for the circumstances to accomplish the development described in the attached SOW. In addition, United Defense shall provide the technical and support people, either employees or subcontractors, that it judges necessary to supplement the work force provided by TACOM-ARDEC in order to complete performance on time and within budget. United Defense will provide narrative performance input to the appropriate government supervisor for consideration in the preparation of the annual performance appraisal of those government employees jointly identified as critical to the successful completion of this development effort within technical, quality, cost and schedule performance objectives.

c. United Defense retains the responsibility to determine the most effective and economical method of attaining the fabrication of the cannon and gun mount subsystems.

d. United Defense agrees to utilize those commercial practices which facilitate the successful accomplishment of the Crusader cannon and gun mount design and engineering development objectives within the cost and schedule constraints of its prime contract (DAAE30-95-C-0009).

e. United Defense will provide and maintain current the names of the technical point-of-contact for the described development, as well as the Statement of Work Manager point-of-contact. The former will serve in a technical direction capacity much like a Government Contracting Officer's Technical Representative (COTR). The latter is the only authority within United Defense empowered to change the scope of work, period of performance, or cost.

Where United Defense's approval is required under the terms of this MOA, it shall be construed to mean the approval of United Defense's Statement of Work Manager. In the event TACOM-ARDEC effects any change at the direction of any other person, the change will be considered as having been made without authority, and an adjustment will not be made in the estimated cost or delivery schedule as a result thereof. No agreement or understanding will be binding on United Defense unless made in writing and signed by the Statement of Work Manager.

f. If the prime contract is novated, United Defense may assign this MOA to a firm or corporation: (1) which succeeds to United Defense's entire business, (2) which succeeds to the business of the Armament Systems Division of United Defense, or (3) into which United Defense may be merged or with which United Defense may be consolidated.

g. Information provided by the government under the terms of this MOA will be governed by the terms of the prime contract (DAAE30-95-C-0009). Certain information and data that may be furnished under this MOA may be subject to 10 USC 4542, as well as the Arms Export Control Act and International Traffic in Arms Regulation (ITAR). United Defense agrees to comply with all statutory, regulatory and contractual requirements regarding the use and disclosure of such information or data.

It is also recognized that the United States Government has patents and patent applications pending regarding inventions related to the SOW. United Defense agrees not to use or disclose any information related to such patent applications without the express written approval of TACOM-ARDEC.

This restriction shall not apply in the event that United Defense obtains such information legally from another source.

The prime contract terms and any license agreement entered into by the parties will control any rights either party may have to technical data, computer software, and/or patents.

V. TACOM-ARDEC Responsibilities:

a. TACOM-ARDEC agrees to undertake the design and development engineering work described in the attached detailed SOW. In the execution of this development, TACOM-ARDEC shall be responsible for meeting all technical, quality, cost and schedule performance objectives. During the course of the development, should it be determined by United Defense that these objectives are not being met, TACOM-ARDEC shall take those actions, within statutory constraints, necessary to anticipate and correct such deviations to include, but not necessarily limited to, the reallocation of other governmental resources to meet program requirements.

b. TACOM-ARDEC will prepare an organization within the IPPD environment. TACOM-ARDEC and United Defense will jointly identify the critical skills and capabilities essential to the successful execution of this MOA and the SOW. TACOM-ARDEC will also identify a Technical Development Project Officer (DPO) who, in response to the technical and programmatic direction of United Defense, will provide the leadership and coordination for all the TACOM-ARDEC effort required by the SOW. TACOM-ARDEC agrees to maintain Government employees on this development effort possessing such skills and capabilities essential to the performance of this MOA and the SOW. In the event that United Defense determines that TACOM-ARDEC is not fulfilling this obligation, United Defense shall promptly notify TACOM-ARDEC, which will take immediate action to remedy the situation. United Defense may, at its option, either provide its own employees or subcontractor employees to supplement the work force provided by TACOM-ARDEC, or may terminate this arrangement in accordance with the clause hereof entitled "Termination."

c. TACOM-ARDEC shall consolidate all Government employees that are needed to work on the Crusader cannon and gun mount subsystems in accordance with the attached SOW into development team(s), collocated into facilities which will be provided by TACOM-ARDEC at no cost to this MOA or the United Defense prime contract. The locations chosen shall be capable of accommodating the cannon and gun mount subsystems teams including United Defense management and engineering personnel and representatives of other subcontractors selected by United Defense.

If the Crusader cannon and gun mount subsystems design and engineering teams are located at either Picatinny Arsenal or Benet Laboratory, TACOM-ARDEC shall ensure that the teams are considered an integral part of the Arsenal or Benet Laboratory, and by their presence, shall not be subject to installation support assessments or charges.

If Government employees are to be permanently located at Armament Systems Division's facilities for the execution of this MOA, they will receive the same level of support for the conduct of their work as is provided to United Defense employees.

d. TACOM-ARDEC shall arrange for United Defense employees and subcontractors to have the same access to the Picatinny Arsenal and Benet Laboratory facilities, and other facilities associated with the development, design, test, and fabrication of the Crusader cannon and gun mount subsystems as that of TACOM-ARDEC employees.

e. TACOM-ARDEC shall provide the administrative and infrastructure support services necessary for United Defense employees and subcontractors to effectively participate as leaders and members of the Crusader cannon and gun mount subsystems development teams. The expectation is that the support shall be the same as that provided to the government members of the team. This support includes, but is not limited to, access to requisite engineering tools which are compatible with those utilized in the Crusader program, access to the Crusader Contractor Integrated Technical Information Service (CITIS), electronic mail, telephone service, copy machines, and regular mail service. In the event that requested support or services cannot be provided by TACOM-ARDEC, then TACOM-ARDEC agrees to facilitate the provision of such essential services at the expense of United Defense or its subcontractors.

f. TACOM-ARDEC agrees to conduct the described development within the United Defense established Common Development Environment for CAD/CAM/CAE. Additionally, TACOM-ARDEC shall provide all data (working and release) on the CITIS within three (3) days of its creation.

g. During the execution of this MOA, TACQM-ARDEC will notify United Defense prior to the procurement of goods and services required to perform this development in accordance with Attachment 2. Should it be agreed that goods and services are required from other Government agencies, TACOM-ARDEC will ensure that they are acquired in an expeditious manner and at the most favorable cost. Should it be determined that the goods and services are required from commercial sources, United Defense will determine which party can most cost effectively acquire them in accordance with the agreed to development schedule. The quality requirements of the SOW are applicable to both Government agencies and commercial suppliers.

h. TACOM-ARDEC agrees to facilitate United Defense's consultation with foreign experts for the purpose of evaluating the TACOM-ARDEC progress on the Crusader cannon and gun mount subsystems and for providing technical direction for the development effort. Such facilitation will be done at United Defense's request consistent with the terms of 10 USC 4542

and in accordance with applicable security regulations and the Crusader Security Classification Guide.

i. TACOM-ARDEC shall provide cost, schedule and quality of technical performance information as required by the SOW to United Defense in a format that is compatible with United Defense's required cost, schedule and technical performance reports. Cost and performance reporting will be accomplished using Open Plan and Micro Frame software. The former will be provided by United Defense under its license arrangements, while the latter will be acquired by TACOM-ARDEC. Such reports will be timely, accurate, current, complete, and of high quality.

j. TACOM-ARDEC personnel will support and participate in those management, quality, technical and performance reviews specified by United Defense in the SOW.

k. TACOM-ARDEC understands that maintaining their cost at budgeted levels and the schedule as set forth in the SOW are critical to the Crusader program. If TACOM-ARDEC fails to control their costs or adhere to schedule, United Defense may exercise its rights under the clause hereof entitled "Termination."

l. In the computation of the labor rate for the assigned government staff, no general and administrative costs will be added to the rate computation.

m. If United Defense discloses to TACOM-ARDEC or grants to TACOM-ARDEC access to any research, development, technical, economic, or other business information or "know-how" of a proprietary nature, whether reduced to writing or not. TACOM-ARDEC will not use any such information or disclose it to any other person, firm, or government, at any time without United Defense's written consent and as otherwise excepted by law. Upon completion of the requirements of this MOA or upon earlier termination hereof, all such proprietary information shall be returned to United Defense. Such completion or termination shall not relieve TACOM-ARDEC of its continuing obligation to protect the information as provided above.

n. TACOM-ARDEC agrees to enter into proprietary information agreements with any third party if it is necessary, in the performance of this MOA or SOW, for TACOM-ARDEC to have access to such third party's proprietary information.

o. TACOM-ARDEC agrees not to release information received in the performance of this MOA or developed pursuant to this MOA without the approval of United Defense, except as otherwise required by law. This includes any briefings, presentations and reports for release at open forum technical symposiums and conferences. This provision is not to be interpreted so as to preclude the normal reporting responsibilities the government development team has to its superiors.

p. During the term of this MOA, TACOM-ARDEC may take possession of government-owned and/or contractor-owned property for which United Defense is accountable. TACOM-ARDEC shall be responsible for the care, control and accounting of such property.

If TACOM-ARDEC previously acquired property that will now be utilized during the performance of the work described by this MOA and SOW, any obligations due any third party, to include other government agencies, for work or property related to this MOA that was begun before the effective date of this MOA, those obligations shall be the responsibility of TACOM-ARDEC and shall be at no cost to this MOA or to United Defense's prime contract.

VI. Transition:

a. United Defense and TACOM-ARDEC agree that this MOA should continue in existence as long as it is beneficial for the effective and cost efficient development and life cycle support of the subsystems covered by the statements of work attached hereto. Both parties agree to mutually work toward the achievement of that development.

b. At a time chosen by United Defense, the Crusader cannon and mount subsystems to include the technical data packages, if applicable, shall transition from TACOM-ARDEC to United Defense. At that point, United Defense shall not only continue to lead the cannon and gun subsystem teams, but shall also perform the work remaining on the final technical data package.

c. The parties agree that this provision does not grant United Defense any licensing rights but rather expresses the intent of TACOM-ARDEC to consider United Defense's application for an exclusive license should a properly documented application be submitted by United Defense. United Defense agrees that their application must comply with all federal law, including 35 USC 207-209, and that federal law requires, among other conditions, that an exclusive license with United Defense "is a reasonable and necessary incentive to call forth the investment of risk capital and expenditures to bring the invention to practical application or otherwise promote the invention's utilization by the public." TACOM-ARDEC agrees to use its best efforts to obtain the granting of the license rights as requested by United Defense. United Defense, L.P., has requested an exclusive, irrevocable, royalty-free, world-wide license to make, use, and sell the Crusader cannon and gun mount subsystems when it is employed on the Crusader system, the M109 family of vehicles, or any application for which United Defense, L.P., has specifically adapted the Crusader cannon and gun mount subsystems for a foreign military system. In addition, it is the intent of the parties to grant United Defense, L.P., a nonexclusive, irrevocable, world-wide license to make, use, and sell the Crusader cannon and gun mount subsystems for any other application. The United States Government (USG) shall retain the right to use and have used the licensed technology and to make or have made items covered by the licensed technology for its own use. The USG retains the right to conduct Foreign Military Sales (FMS) which require the use of the proposed licensed technology. In such cases, however, the USG agrees that the Crusader cannon and gun mount will be obtained from United Defense, if United Defense has been

granted the exclusive rights to such technology and if such sole source is authorized by law and approved by the appropriate USG official, unless the United States Army determines under 10 USC 4532(a) that the cannon and gun mount are to be made in a USG-owned factory or arsenal.

This license shall be in effect until twenty (20) years after the Crusader system has achieved Initial Operational Capability (IOC). Since practical application of the Crusader cannon and gun mount subsystems will not be achieved for many years, the Government may not terminate the license pursuant to 35 USC 209(f)(2) until ten (10) years after achievement of IOC of the Crusader system. The parties recognize that these specific time periods shall be limited by the life of the patented technology.

TACOM-ARDEC agrees, in principle, with the above licensing terms. However, both parties understand that TACOM-ARDEC is required by Federal statute to, among other things, provide public notice and opportunity for written objections before it can grant such a license. TACOM-ARDEC agrees to immediately begin the process of making such public notice and to do all things necessary to expedite the licensing process toward an approval date of June 30, 1997. TACOM-ARDEC also agrees to vigorously support the granting of a license to United Defense which includes the terms set forth above.

VII. Nature of Agreement:

This is a memorandum of agreement between TACOM-ARDEC and United Defense. Any enforceable rights which United Defense may have are limited solely to those rights existing under the development contract. In that TACOM-ARDEC is performing work for the Crusader program, TACOM-ARDEC will be reimbursed with funding that was planned for United Defense's prime contract (DAAE30-95-C-0009) but which will now be transferred directly from the OPM Crusader to TACOM-ARDEC.

VIII. Termination:

a. Should issues of performance, cost control, schedule, and/or risk arise, United Defense will address them with TACOM-ARDEC and provide TACOM-ARDEC a reasonable opportunity to correct the situation.

b. United Defense, upon determination that the lack of performance or poor performance by TACOM-ARDEC on the advanced solid propellant cannon and/or gun mount subsystems places Crusader Program success at risk, has the right to terminate TACOM-ARDEC's work, in whole or in part, under this MOA and SOW. In the event that such a determination is made, United Defense will direct the OPM Crusader to terminate funding immediately and to recover any unearned balances within five (5) days. United Defense will determine the most appropriate and cost effective manner to continue the development of the advanced solid propellant cannon and/or gun mount subsystems. In the event of termination, TACOM-ARDEC agrees to cooperate in any way necessary and legally authorized to ensure a trouble-

free transition from development by TACOM-ARDEC to development by United Defense or a subcontractor.

c. This MOA will remain in effect until the successful completion of all attached statements of work unless rescinded, superseded, or terminated by mutual agreement of the parties, or by United Defense in accordance with paragraph VIII b above, or by United Defense unilaterally if its prime contract is terminated, modified or constructively changed by the Government.

d. In the event of a termination of this MOA under this Article, ARDEC will have no right to recover termination expenses directly from United Defense.

IX. Changes

a. The addition of new statements of work to this MOA shall be by mutual agreement as set forth in Article II above.

b. Changes to approved statements of work will be made as set forth below:

1. United Defense may at any time, by written order make changes within the general scope of the MOA in any one or more of the following:

(a) Drawings, designs, or specifications.

(b) Method of shipment or packing.

(c) Place of inspection, delivery, or acceptance.

(d) Any part of the SOW if the change(s) result from changes to the prime contract that effect the SOW.

2. If any such change causes an increase or decrease in the estimated cost of, or the time required for, performance of any part of the work under this MOA, whether or not changed by the order, or otherwise affects any other terms and conditions of this MOA, United Defense shall make an equitable adjustment in the (a) estimated cost, delivery or completion schedule, or both, and (b) other affected terms and shall modify the MOA accordingly.

3. TACOM-ARDEC must assert its right to an adjustment under this article within 30 days from the date of receipt of the written order. However, if United Defense decides that the facts justify it, United Defense may receive and act upon a proposal submitted after that date.

4. Failure to agree to any adjustment shall be resolved under the Issues Resolution Article below. However, nothing in this clause shall excuse TACOM-ARDEC from proceeding with the MOA as changed.

5. Notwithstanding the terms and conditions of paragraphs 1 and 2 above, the estimated cost, and, if this MOA is incrementally funded, the funds allotted for the performance of this MOA, shall not be increased or considered to be increased except by specific written agreement indicating the new estimated cost and, if this MOA is incrementally funded, the

new amount allotted for this MOA. Until this agreement is reached, TACOM-ARDEC shall not be obligated to continue performance or incur costs beyond the point established in the Limitation of Funds Article of this MOA.

X. Issues Resolution

a. Both parties agree to attempt to mutually resolve any issue arising under or related to this MOA at the lowest practicable level within the integrated product development team. The parties recognize that the IPPD environment is a setting where issues will frequently arise. However. the IPPD level is frequently the most informed and intimate with the details of the issue and hence the most capable of resolving issues related to the development. Since United Defense and TACOM-ARDEC have agreed to conduct the development through IPPD, their respective managers and leaders are empowered to resolve the issues they confront.

b. Any issue which is not disposed of by agreement of the parties within the integrated product development team shall be referred for resolution to the Crusader Development Executive Committee (see Article XI). Issues referred to the Crusader Development Executive Committee will be presented to and addressed by that body within 30 days of determination by the integrated product development team that it cannot resolve the issue.

c. Pending the resolution of any issue arising under or related to this MOA, TACOM-ARDEC shall proceed diligently with the performance of this MOA and attached SOW.

d. If issues are not resolved to United Defense's satisfaction, United Defense reserves the right to terminate this MOA under Article VIII.

XI. Executive Committee

a. The precedent setting nature of the initiative represented by this MOA and the impact on the Crusader program of the relationship between United Defense and TACOM-ARDEC suggest exploiting all avenues to ensure success. Furthermore, United Defense and TACOM-ARDEC agree that this MOA should continue as long as it is beneficial for the effective and cost efficient development and life cycle support of the subsystems covered by the statements of work, the parties agree that it would be beneficial to establish a Crusader Development Executive Committee (CDEC).

b. The CDEC is created to:

Provide senior level review of joint performance under terms of the MOA and attached statements of work.

Review and update the MOA, as required.

Resolve issues beyond the resolution scope of the managerial and working level staff.

Promote and strengthen the relationship initiated by this MOA between United Defense and TACOM-ARDEC.

c. The CDEC will be made up of executive level representatives of the signatories to the MOA, United Defense and TACOM-ARDEC. They include the incumbents of the following offices:

United Defense	TACOM-ARDEC
Crusader Program Director	Technical Director
Crusader Deputy Program Director	Commander/Director, Fire Support Armament Center
Crusader Technical Director	Director, Benet Laboratory

Other representatives, as observers, may be invited by the Chairman to attend a meeting of the CDEC when the agenda warrants their participation.

d. The CDEC will be chaired by the Crusader Program Director and will meet in Minneapolis at least twice annually, or more frequently at the call of the Chairman.

XII. Limitation of Funds

a. The parties estimate that performance of the attached SOW will not cost the Government more than the estimated cost negotiated by United Defense and TACOM-ARDEC. TACOM-ARDEC agrees to use its best efforts to perform the work specified in the SOW and all obligations under this MOA within the estimated cost.

b. United Defense will specify, through instructions to OPM Crusader, the amount of funding presently available for payment and allotted to the SOW, the items covered, and the period of performance it is estimated the allotted amount will cover. The parties contemplate that OPM Crusader, at the instruction of United Defense, will allot funds incrementally up to the full estimated cost. TACOM-ARDEC agrees to perform, or have performed, work on the SOW up to the point at which the total amount paid and payable by OPM Crusader approximates but does not exceed the total amount allotted to the SOW.

c. TACOM-ARDEC shall notify United Defense in writing whenever it has reason to believe that the costs it expects to incur in performance of the SOW in the next 60 days, when added to all costs previously incurred, will exceed 75 percent of the total amount so far allotted to the SOW. The notice shall state the estimated amount of additional funds required to continue performance for the period specified in the MOA.

d. OPM Crusader is not obligated to reimburse TACOM-ARDEC for costs incurred in excess of the total amount allotted by OPM Crusader for performance of the SOW. TACOM-ARDEC is not obligated to continue performance of the SOW or otherwise incur costs in excess of the amount then allotted to the SOW by OPM Crusader, until OPM Crusader, at United Defense's instruction, notifies TACOM-ARDEC in writing that the amount allotted has been increased and specifies an increased amount, which shall then constitute the total amount allotted by OPM Crusader to the performance of the SOW.

XIII. Responsibility for Items

Risk of loss or damage to government or contractor acquired property shall remain with the Government until, and shall pass to United Defense upon, acceptance by United Defense.

XIV. Notices and Correspondence

All notices and correspondence shall be sent by either party to the other in all matters dealing with this MOA to the following addresses:

United Defense, L.P.
Armament Systems Div' ion
4800 East River Road
Minneapolis, MN 55421-1498
Attention: Phillip Kuechenmeister, M389
Title: Statement of Work Manager

US Army Armament Research, Development and Engineering Center
ATTN: AMSTA-AR-FSA-C
Building 61N
Picatinny Arsenal, NJ 07806-5000
Attention: Barbara J. Machak
Title: TACOM-ARDEC Crusader Development Management Officer

XV. Responsibilities of the Parties

The parties will, in good faith, carry out the obligations set forth in this MOA and attached SOW. They shall exert all reasonable and proper efforts to negotiate the SOW in good faith.

XVI. Acceptance

This document sets forth the entire agreement between the parties relating to the subject matter hereof, and any earlier understanding, agreements or promises by United Defense and TACOM-ARDEC are superseded by this MOA.

UNITED DEFENSE, L.P.
Armament Systems Division

UNITED STATES OF AMERICA
U.S. Army TACOM-ARDEC

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